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APOLLO 9
30-DAY FAILURE AND ANOMALY LISTING REPORT

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MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

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30-DAY FAILURE AND ANOMALY LISTING REPORT

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INTRODUCTION

This report contains a discussion of the significant anomalies noted during the Apollo 9 mission. The discussion of these items is divided into three major areas: command and service modules, lunar module, and government-furnished equipment. The status of the open anomalies will be maintained in the Anomaly Status Report.

COMMAND AND SERVICE MODULES

PROPELLANT ISOLATION VALVE CLOSURES

Following separation from the S-IVB, the crew reported a control problem which had lasted for about 12 minutes during the transposition period. The crew first noticed a lack of capability for translation to the left. The position indicator flags for the quad C primary and secondary propellant isolation valves and the quad D secondary valves were in the "barber pole" or closed position (fig. 1). The valves were opened and the system performed normally thereafter. These valves had been opened during final checks prior to launch and were verified to be open by the crew just prior to separation from the S-IVB.

Propellant usage and quad temperature data showed that all four quad C valves were closed and that quad D was performing normally before the crew opened the propellant isolation valves. Propellant may be supplied from either the primary or secondary tanks and only the secondary tank valves were closed on quad D. Angular rate data transmitted shortly after the valves were opened verified normal operation of quad C.

The following possibilities explain the valve closures:

1. Momentary, inadvertent switch actuation by the crew - This is not very likely, as both the Commander and the Command Module Pilot made a cursory check of the panel after they exchanged seats, and neither noted any discrepancies.

2. Momentary switch closure caused by contamination - No particulate contamination was found in the switches.

3. Electrical transients - This has been discounted because of the power required.

4. Reduced latching force - The propellant isolation valves in the command module reaction control system are identical to those in the service module system. To determine whether the magnetic latching force of

the valves could have been deteriorated, the valves on command modules 103 and 104 and those from several ground tests were checked. Results compared favorably with original acceptance test data on those particular valves.

5. Valve closure caused by mechanical shock at separation of the command and service modules from the adapter - Shock tests were run on a service module reaction control system valve to establish the level of shock that would be necessary to cause a normal valve to close. A cross sectional view of the valve is shown in figure 2. Results of the test indicate that a shock of about 80g could cause a valve to close. The shock resulting from the pyrotechnic charges used to separate the command and service modules from the adapter may have been between 40 and 100g (analyses to refine these values are in progress).

The most probable cause of the inadvertent closure was the shock at separation from the adapter. Apparently, the shock is of sufficient magnitude, direction, and location that it could have caused these valves to close. The particular valves that might close are a function of the normal latch force of the valves in question and the attenuation and direction of the shock from the separation at the location of the valve.

The Apollo Operations Handbook (AOH) will be changed to insure that the crew check the propellant isolation valves immediately after separation and that they reopen any valves which may have closed.

This anomaly is open.

SCANNING TELESCOPE SHAFT DRIVE PROBLEM

The "degrees" drums of the telescope shaft angle counter on the optics control panel froze at 64 degrees on the first day of the mission. The "tenths" drum continued to rotate (fig. 3). During an alignment of the inertial measurement unit on the second day, the shaft drive mechanism stopped intermittently. In some cases, the universal tool had to be used to operate the optics manual adjust screw to free the mechanism. The drive mechanism persisted in jamming intermittently until the fifth day, after which the problem disappeared.

The optical unit assembly was removed from the spacecraft, and electrical drive tests showed that the drive mechanism was free. When the unit was disassembled, the pin from the "tenths" drum of the counter geneva mechanism drive (fig. 4) was found wedged in a split gear on the drive shaft of the one speed resolver in the telescope gear box.

The problem resulted from an out-of-tolerance condition on the hole into which the pin was press-fit. The counters for command modules 106 and subsequent and lunar modules 5 and subsequent will be replaced with units which have been specifically inspected for this condition. This anomaly is closed.

LOSS OF AUTOMATIC CRYOGENIC HYDROGEN PRESSURE CONTROL

During the flight, the automatic pressure control system in the hydrogen tanks failed. The logic of the control system (fig. 5) is such that the pressure switches in both tanks must close in order for the heaters to be activated; however, opening of only one pressure switch will deactivate the heaters. The first indication of failure was noted at 93 hours, shortly after the initial undocking, when the heaters were not automatically activated (fig. 6). At approximately the time of the final lunar module undocking, all hydrogen tank heaters came on and pressurized the tanks to about 270 psia, which required that the heaters be turned off manually.

As a result of the automatic pressure control system failure, the hydrogen pressure was controlled using the manual mode throughout the remainder of the mission.

Since the first failure (failure to turn on) would have required one pressure switch to fail open and the second failure (failure to turn off) would have required that both pressure switches fail closed, the switches can be ruled out. The most probable cause for the failures was an intermittent condition in the motor or its control circuit (including the power line, ground, and the terminal board for 16-gage pins) resulting from the undocking shock (see fig. 5). Sixteen-gage terminal boards have been the source of intermittent contact during vehicle ground tests.

No corrective action will be taken for Apollo 10; the tank pressures can be controlled manually by either the heaters or the fans if the automatic system fails.

This anomaly is closed.

ERRONEOUS DOCKING PROBE INDICATIONS

During initial undocking, the Command Module Pilot placed the probe-extend/release-retract switch to extend/release, and the vehicles began to separate, indicating release of the probe-extend latch. However, the vehicles did not physically unlatch until the third attempt. Indications are that the switch was not held in position long enough for a separating force to effect physical separation.

The second discrepancy occurred prior to the lunar module docking maneuver, when the Command Module Pilot placed the switch in the retract position in preparation for docking. In this position, the display showed "barber pole," indicating that the probe was not cocked for docking. This is further evidence that the extend/release-retract switch was not actuated for a sufficient time to allow the docking probe to fully extend. Cycling the docking mechanism produced the proper gray display indication.

The design will allow the latches not to cock during undocking if the release motors are not energized sufficiently long for the latches to spring back to proper attitude for cocking. The system returns to the uncocked (latches-locked) configuration which exists when docked.

The Apollo Operations Handbook (AOH) has been changed to include the requirement for holding the extend/release-retract switch in the extend/release position until physical separation.

This anomaly is closed.

MULTIPLE COMMANDS NOT ACCEPTED

At approximately 109 hours, the spacecraft would not respond to multiple uplink real-time commands. Ten hours later, the crew cycled the power switch to the command system, restoring normal operation (fig. 7). The first of multiple commands was received by the command receiver; however, a message acceptance pulse was not transmitted to the ground receiver, which in turn sends a signal to the ground transmitter to send the next command. The ground override function was used on several occasions to transmit the next command; however, the spacecraft still did not respond. The problem existed over numerous ground stations and also was experienced once preflight; consequently, it has been isolated to the flight hardware. As yet, no conclusion can be drawn as to the cause of the discrepancy. Testing of the spacecraft hardware is to be completed by April 25. However, no corrective action is anticipated for spacecraft 106.

This anomaly is open.

ENTRY MONITOR SYSTEM FAILURE

The entry monitor system stylus did not continuously cut through the emulsion on the scroll assembly. The accelerometer output of the entry monitor drives the stylus to scribe the acceleration (g) history versus velocity. The emulsion on the Mylar scroll film is cured and kept in a dry atmosphere by enclosing the scroll assembly inside a sealed case under one atmosphere of dry neon gas to maintain the proper consistency of the emulsion (see fig. 8). The characteristics of the emulsion change if moisture is absorbed, causing the substance to harden.

A leak was found in the scroll assembly postflight; the leak would allow the case to breathe moisture inside. A leak-tested scroll assembly, with a finer stylus point which will penetrate harder emulsions, and several other minor modifications will be installed in Apollo 10.

This anomaly is closed.

INDICATED SERVICE PROPULSION PROPELLANT UNBALANCE

During the third firing of the service propulsion engine, there were eight master alarms from the propellant utilization and gaging system indicating an excessive propellant unbalance (fig. 9).

All the master alarms are explainable. The first alarm was caused by propellant level in the capacitive measuring tube not reaching the settled level soon enough after start-up. The next five alarms, shown in figure 9, resulted from an electrical zero bias in the oxidizer measuring circuit after storage tank depletion. Thus, continuous alarms on the primary gaging system caused the crew to switch to the auxiliary system, which employs point sensors at discrete levels in the tanks.

A legitimate unbalance caused an alarm during the auxiliary system operation, as noted. Also, switching back to the primary system resulted in another legitimate alarm, even though the zero bias existed.

Master alarms and caution and warning indications from the propellant utilization and gaging system are not required. Consequently, these functions have been cut from the system for spacecraft 106 and subsequent, as shown in figure 10.

A calibration and appropriate adjustment will be made during preflight servicing to compensate for the zero bias at tank crossover. Additionally, procedures have been changed for the crew to ignore the unbalance during the first 25 seconds of a firing to allow sufficient time for propellant settling.

This anomaly is closed.

MASTER ALARM DURING DOCKING

A master alarm without a caution and warning annunciator occurred coincident with docking. No input was identified as being in the range of the caution and warning system at that time. The fact that the alarm did not occur at physical contact but during the hard docking rules out static discharge between the two vehicles and indicates a shock-sensitive condition. The master alarm system is very sensitive to trigger signals and requires only a 5-microsecond pulse to initiate an alarm. The caution and warning lights require a continuous input to illuminate. A shock-sensitive intermittent condition in one of about 60 inputs could trigger the alarm.

The caution and warning system has been removed for testing to determine whether any of the components are shock-sensitive or whether any out-of-tolerance condition exists.

During docking tests at the launch site, three unexplained master alarms were experienced on spacecraft 106. One was associated with actual contact of the lunar module with the command and service modules. Therefore, a recurrence is likely during the Apollo 10 mission. No corrective action is anticipated for Apollo 10 at this time.

This anomaly is open.

FUEL CELL 2 CONDENSER EXIT TEMPERATURE

The condenser exit temperature for fuel cell 2 was outside the normal range (155° to 165° F) on numerous occasions. This condition was similar to that observed on Apollo 7. Analysis shows that the travel of the secondary coolant regenerator bypass valve (fig. 11) was restricted between approximately 4 and 10 percent bypass between 88 and 191 hours. The condenser exit temperature remained within normal operating limits at all loads after 191 hours. The loads after that time were relatively high, requiring normal bypass valve modulation between 8 and 19 percent.

Previous ground tests and analysis of coolant drained from vibration and flushing operations of other spacecraft show that coolant loop contamination buildup in the valve caused the restricted travel of the bypass valve. This contamination is present in the form of gelatinous phosphates and/or solid particles.

For Apollo 10, the radiators will be vibrated and a volume exchange made 30 to 45 days prior to launch (the Apollo 9 spacecraft had only a volume exchange 45 days prior to launch). An in-line change to use the block I bypass valve, which is less susceptible to contaminants, has been made.

This anomaly is closed.

DOCKING SPOTLIGHT FAILED

The Command Module Pilot reported during the lighting check prior to rendezvous that the docking (exterior) spotlight on the service module did not operate. Photographs of the vehicle during rendezvous showed that the light did not deploy. The circuit breaker for deploying the light was open at launch, as specified, to prevent inadvertent deployment, and the breaker had not been closed prior to the attempt to deploy the light (the crew checklist did not include closure of the breaker). Other circuits powered through this breaker were either redundant or were not used until later in the mission. Later, the breaker was closed for operation of the right-hand crewman optical alignment sight, and the sight installation operated properly.

The crew checklist has been changed to include closing of the circuit breaker prior to spotlight deployment.

This anomaly is closed.

INTERNAL FLOODLIGHT MALFUNCTIONS

The crew reported that three of the six internal floodlights malfunctioned during the mission. One became extremely hot and emitted an odor. Postflight testing revealed that the primary lamp in the right lower equipment bay failed. The primary lamp cathode had completely disintegrated, indicating that the lamp had been operated excessively between full dim and full bright, which greatly reduces the lamp life and causes a diode to fail.

Because of a broken wire, the secondary lamp on the left-hand couch would not operate.

The lamp on the right-hand couch was reported to be extremely hot and emitted an odor. There was touch-up paint on the lamp, and during postflight operation, the touch-up paint did emit an odor. The heat emittance will be established by tests in progress.

Several lamps have been changed on Apollo 10 because of use beyond a 100-hour limit for test and checkout. Lamp operation has been restricted in the Test and Criteria Document to the dim 2 position. This anomaly is open pending completion of the heat tests.

COMPUTER RESPONSE TO DSKY ENTRIES

The crew reported two occasions in which the computer did not receive and act upon data entered through the display and keyboard assembly (DSKY). The first case involved a digital autopilot configuration change before the sixth service propulsion maneuver. The data required to incorporate the intended change were keyed into the DSKY and observed on the DSKY display. Depression of the ENTER key was reported, but the autopilot configuration did not change. The second case occurred during a spacecraft power-down period when Verb 46 ENTER, which deactivates the autopilot, was unsuccessful. The two occurrences are different in that different failure or procedural error characteristics would be required to produce the reported symptoms. A depression of the ENTER key transmits a 5-bit keycode to the computer, which then takes appropriate action corresponding to the data previously keyed into and displayed on the DSKY. At the same time, the computer causes the DSKY to blank or change to the next display if under program control. Depression of the ENTER key will not blank the DSKY unless the proper keycode is received by the computer. Depression of other keys may blank all or part of the DSKY, depending on the situation (i.e., a CLEAR key blanks the data registers, a VERB key blanks the verb display, and a PROCEED key will blank or change to the next display). All require proper receipt of information and action by the computer.

In the first case, the depression of the PROCEED key instead of an ENTER would have caused the symptoms and results reported. In the second case, if a Verb 46 was keyed in, only another VERB key depression would have blanked the DSKY without entering the data. Another possibility would be entry of a verb which causes no action at all or an action which is undetectable. Possible verbs which fit this category are V45E, V47E, V56E, V66E, V76E, and V86E.

No hardware or software failures that could have caused these conditions have been identified. Procedural errors of the type discussed could have caused the failure conditions. However, the crew considers it unlikely that such errors were made.

This anomaly is closed.

SURGE TANK SHUTOFF VALVE

The repressurization of the surge tank required an excessive length of time. Nominal repressurization was achieved when the crew repositioned the tank shutoff valve. During the systems debriefing, the crew stated that they believed no mechanical problems existed with the valve but that the decal marking was misaligned with the valve detent position. Postflight, the valve positions were checked and found to be misaligned by 30 degrees. Spacecraft 106 has been checked for proper alignment.

This anomaly is closed.

DOCKING RING SEPARATION CHARGE HOLDER

One docking ring separation charge holder was deformed and out of its channel, extending several inches beyond the periphery of the external tunnel structure (fig. 12). Such a configuration might foul or cut the nylon riser lines during parachute deployment.

The charge holders are two semicircular steel rings attached at one end with the other end free. They normally remain in a channel about an inch deep on top of the remaining tunnel structure. During ground tests, the free end of these holders occasionally came out of the channel but never deformed to the extent experienced on Apollo 9. It is not known whether the deformation occurred during descent or during recovery operations.

A retainer spring design (fig. 13) has demonstrated that during separation, it will retain the charge holder without the lunar module attached. This design will be incorporated on spacecraft 106.

This anomaly is closed.

LUNAR MODULE

DESCENT PROPULSION REGULATOR MANIFOLD PRESSURE DROP

During the first 30 seconds of the first descent engine firing, the descent propulsion helium regulator manifold pressure decayed to 180 psi and recovered to a normal value of 240 psia. All temperature, pressure, and flow indications substantiate a plugged heat exchanger in the supercritical helium system (see fig. 14); the plugging cleared during the firing (see fig. 15), as indicated by the pressure rise in the supercritical helium tank and the return to normal regulated pressure.

After the supercritical helium servicing at the launch complex, the tank fill and vent quick-disconnects are purged with helium to insure that the quick-disconnects are dry before being capped. The purge helium is supplied from the same regulator that is supposed to maintain the manifold pressure above 5 psig.

During the LM-3 servicing, the pressure must have dropped to zero, allowing air to be drawn into the manifold by condensing out the incoming air in the supercritical helium tank heat exchanger. Tests have shown that dropping the manifold pressure to zero for about 30 minutes will allow air to be "cryo-pumped" into the manifold to the tank heat exchanger, where it will freeze and block the heat exchanger. The freezing process transfers heat into the supercritical helium tank, causing a pressure rise of about 90 psi, very similar to what occurred during the LM-3 top-off (see fig. 16). If no air were introduced, the tank pressure would be expected to rise 10 psi or less.

The ground support equipment has been modified for Apollo 10 and subsequent to isolate the purge system from the manifold pressure control system. Further, continuous pressure recording with proper scaling will be employed on the manifold. Additional equipment may be supplied to provide the capability to test for blockage of the tank heat exchanger. Servicing procedures using the new ground support equipment configuration will be demonstrated. The new equipment and servicing procedures will then be shipped to the launch site for Apollo 10.

This anomaly is closed.

SUPERCRITICAL HELIUM PRESSURE DECAY

The pressure in the supercritical helium tank for the descent propulsion system began decaying at 2.9 psi/hr immediately after shutdown of the first descent engine firing and continued to decay until staging. Because of heat transfer into the tank, the pressure should always increase under no-flow conditions (fig. 17). The pressure decay is indicative of a leak of about 0.1 lb/hr from the helium system. Analysis of the data indicate the leak was upstream of the solenoid valve and probably upstream of the supercritical helium tank heat exchanger.

The flight configuration of helium tank, squib valve, bimetallic fitting, and associated plumbing has not been tested together for response to squib valve firing shock (fig. 18) other than the LM-1 flight, which showed no sign of leakage. A test is being run on the LM-4 flight configuration to determine whether or not the components from the tank to the fuel heat exchanger have sufficient strength margin for thermal, vibration, and squib valve firing shock.

The LM-3 squib valve differed from the LM-4 configuration in that the LM-3 valve fittings were internally brazed, preventing proper inspection of the joint. The LM-4 fittings are externally brazed (fig. 19).

Testing on the LM-4 configuration will be completed about April 13. If a failure occurs or measured stress levels are excessive, modifications will be incorporated on a second specimen. This test should be completed about April 19.

This anomaly is open.

TRACKING LIGHT FAILURE

The tracking light became inoperative shortly after staging. Possible causes are voltage breakdown in the flash head assembly, breakdown in the high-voltage cable, component failure in the electronics package, or voltage breakdown in the pulse-forming network. Based on failure history, breakdown in the pulse-forming network is considered the most likely cause of the failure. Tests are in progress on a LM-4 tracking light to determine whether that configuration can stand vibration, shock, vacuum, and thermal stress of the LM-4 mission. If the unit fails the mission simulation, a tracking light with a modified pulse-forming network now being manufactured will be installed in LM-4. The modified unit has improvements which should eliminate voltage breakdown under the flight environment.

This anomaly is open.

PUSH-TO-TALK SWITCHES INOPERATIVE

The Lunar Module Pilot's push-to-talk switches, located on the umbilical and on the attitude controller, were inoperative at about 89 hours. The Lunar Module Pilot used the VOX mode for transmitting for the remainder of lunar module operations. Failure of both switches is not probable. The common path on either side of the switches includes switch contacts on the audio section, connectors, and diodes in the signal processor assembly. The problem was probably caused by a discontinuity (broken wire) in the common wire to the parallel push-to-talk switches.

The push-to-talk mode of communication is isolated from the VOX mode of communication. In addition, switching the backup push-to-talk mode will bypass most of the common wiring where the failure may have occurred.

A change for the Apollo Operations Handbook will include malfunction troubleshooting procedures to be used if the problem recurs.

This anomaly is closed.

ABORT GUIDANCE WARNING LIGHT

During the third manning, a caution and warning alarm occurred at activation of the abort guidance system. The caution and warning indication means that one of the following conditions is present:

1. The 12-V dc power supply voltage is out of limits.

2. The 28-V dc power supply voltage is out of limits.

3. The ac power supply voltage is out of limits.

4. The abort electronics fails a self-test.

5. An overtemperature exists in the abort electronics.

6. One of the monitoring circuits (instrumentation) of the five previous items has malfunctioned.

The specification limits for alarms and the operating specification limits of the parameters have sufficient spread that an out-of-specification condition would have caused a malfunction of the abort guidance system.

The most likely cause of the anomaly was either a shorted or broken wire between the abort electronics assembly and the signal conditioning electronics assembly (26 gage wires with seven splices), a failure within a signal conditioning electronics assembly, or a failure in the caution and warning system.

The five abort guidance warning parameters in LM-4 were measured and verified to be within specification limits, with sufficient separation between the operating limits and the caution and warning limits.

This anomaly is closed.

NO INDICATION OF TAPE RECORDER OPERATING

The Lunar Module Pilot reported that the tape recorder (data storage electronics assembly) was not operating properly with the Lunar Module Pilot in the VOX mode. Analysis of the tape indicates that the Commander's audio center was configured for intercommunications ("hot" microphone), and the tape recorder was running continuously, as it should have been. Review of the voice recorded indicates that no anomaly existed.

A gray indication on the flag is a proper operation indication only for track 1 of the four track tape. If no modulation is present on track 1, the flag will be "barber pole" while recording on the other three tracks.

The Apollo Operations Handbook has been changed to clearly describe the operation of the flag indicator associated with the four voice tracks.

This anomaly is closed.

BINDING OF FORWARD HATCH AND FAILURE OF DOOR STOP

The crew reported that when the forward hatch was opened for extravehicular activity, it tended to bind on top and had to be pushed downward to open it. Also, the door would not stay open. Figure 20 shows the potential hatch interference points that could have caused the binding.

Inspection on LM-5 showed that the vehicle front face blanket above and around the hatch opening protrudes below the vehicle fixed structure shielding (in an area where 0.250-inch clearance should exist). This protrusion is in the path of and interferes with the hatch shield lip. LM-4 will be inspected for similar conditions. Corrective action will be to run a strip of tape between the vehicle structure and shield to retain the blanket and prevent it from sagging into the hatch opening.

The door stop (snubber) is attached to the door and is designed to ride against a Velcro patch on the floor, thereby holding the door open. The door stop did not work in flight. Floor shift relative to the door stop in zero-g is being studied to determine whether the door stop can properly ride on the Velcro patch.

This anomaly is open.

HIGH CABIN NOISE LEVEL

The noise level in the cabin was too high. The primary noise sources were the cabin fans, glycol pumps, and suit compressors. Noise measurements were made on LM-8 with the glycol pumps and suit compressors operating. The worst source was found to be the glycol pumps. The pumps couple acoustic energy into the glycol lines and then to the pressure vessel at penetration points. The pressure vessel then amplifies this energy.

Flexible couplings are being studied as a means of minimizing acoustic coupling between the pumps and lines. Tests will be performed in LM-8 to determine their effectiveness. A change to the Apollo Operations Handbook has been made to use only one cabin fan and then only when cooling is required.

No hardware change will be made for Apollo 10, as most of the mission is conducted with helmets on. Hardware changes are being considered for Apollo 11, as the crew will be required to sleep while on the lunar surface.

This anomaly is open.

STRUCTURAL CONTACT AT S-IC SHUTDOWN

Data indicate that the lateral loads introduced at S-IC shutdown caused the helium diffuser flange on the descent propellant tank to contact the sheet metal flange of the upper deck (see fig. 21). Analysis has shown that the contact would not damage either the upper deck sheet metal flange or the heavy diffuser flange or tank boss. Analysis also shows that the tank and plumbing are not over-stressed under this condition. The lower weight of LM-4, in conjunction with the S-IC expected shutdown conditions, will produce less deflection for Apollo 10 than was experienced on Apollo 9. Further studies are underway for Apollo 11 weights and shutdown transients.

This anomaly is closed for Apollo 10.

DATA ENTRY AND DISPLAY ASSEMBLY OPERATOR ERROR LIGHT

The data entry and display assembly operator error light was illuminated frequently during the mission and had to be extinguished by depression of the CLEAR pushbutton. The depression of the button would blank the display. The operator error light would go out but would return upon release of the CLEAR button. Four or five depressions of the button would be required to extinguish the light.

The most likely cause of the condition was a failure of a contact of one of the two switches in the CLEAR pushbutton. A failure of the no. 1 contact to close would prevent the abort electronics assembly from receiving a CLEAR discrete, while the no. 2 contact would function normally, causing the data entry and display assembly to perform CLEAR operations, that is, blank displays, reset operator error logic, etc. The above conditions result in the computer remaining in the readout mode and, consequently, sending SHIFT discretes to the data entry and display assembly. The sending of SHIFT discretes while the assembly is in the CLEAR mode will cause the operator error light to be illuminated.

The two switches associated with the particular CLEAR button had a preflight history of problems. The problems consisted of the two switches not closing simultaneously and/or the pushbutton not depressing fully. The conditions involved with the preflight discrepancies will be explored further. However, no change will be made to LM-4.

This anomaly is closed.

ASCENT PROPULSION HELIUM PRESSURE

At the start of the second ascent propulsion firing, the helium pressure to the propellant tanks regulated at about 177 psia instead of the expected value of 185 psia. At 290 seconds into the firing, the pressure increased from 176 to 180 psia.

Four aspects of the problem must be considered:

1. The lockup pressure was about 190 psia before and after the firing - This satisfies the normal lockup of the primary regulator in leg I, indicating that leg I had at least some flow capability.

2. The level of regulation during flow was about 177 psia up to about 300 seconds - This regulated pressure could have been controlled by either the primary regulator in leg II or the primary regulator in leg I if that regulator down-shifted around 8 psi under flow conditions.

3. During the regulated flow period, the regulated pressure dropped about 1 psi over 300 seconds - The characteristic regulation pressures decrease with a decrease in supply pressure for the primary leg I regulator. In 300 seconds, about a 1-psi pressure drop would be expected for this regulator. On the other hand, the primary regulator in leg II had increasing regulation pressures with a decreasing supply pressure of about 1 psi in 300 seconds. These facts suggest that the primary regulator in leg I was controlling the flow up to about 300 seconds.

4. At about 300 seconds, the regulated pressure increased 3 to 4 psi - This suggests at least one of four conditions:

a. The primary regulator in leg I was controlling (with a down-downshift in regulation), and the down-shift was partially corrected.

b. The primary regulator in leg II was controlling and had an upshift in regulation. This indicates a malfunction in the primary regulator.

c. The primary regulator in leg II was controlling, and the primary regulator in leg I started to control but under down-shifted conditions.

d. The primary regulator in leg I was controlling under down-shifted regulation. The primary regulator in leg II also started to supply flow because of the characteristics of the two regulators reaching the same control pressure. Tests have shown that under these conditions, a rise in regulated pressure can be expected.

Any of these considerations point out a failure in the primary regulator of leg I to maintain expected regulation pressures. Item 4b can be ruled out if two failures of different types in each of the primary regulators can be ignored.

The aspects of items 1 through 4 isolate the problem to the primary regulator in leg I, characterized by a down-shift in regulation which may or may not have partially corrected during the firing.

Several possible failures within the regulator could have caused a down-shift. These will be simulated on a regulator to determine the actual effect on the regulation pressure. These results are expected by April 19. The presently identified types of failure which can cause a down-shift in regulation are not detrimental to the operation of the ascent propulsion system. Consequently, no hardware changes are anticipated for Apollo 10.

This anomaly is open.

ROUGH DESCENT ENGINE THROTTLING

During the second descent engine firing, the engine was rough at about 27 percent throttle for a few seconds, then settled out and operated smoothly during the remainder of the firing. The data during the rough period showed a rise in the oxidizer interface pressure, followed by a rise in the fuel interface pressure, and both subsequently returning to the normal pressure. During this time period, the engine chamber pressure fluctuated, causing the roughness.

Tests have shown that with helium deliberately introduced into the line, the interface pressures increase as the gas passes the throttle assembly. The throttled area operates at cavitating pressures, giving rise to a pressure increase as the helium passes through the area. The variation of interface pressures and the bleeding of helium into the injector result in fluctuation in the engine chamber pressure. These test results match very closely the flight data during the engine roughness.

The helium in the propellant tanks could enter the propellant lines under certain conditions of acceleration. However, a "zero-g" cup over the lines inside the propellant tank greatly reduces the likelihood of helium getting into the feed lines.

In any event, tests have demonstrated that ingestion of helium into the engine in this manner has no detrimental effect on the system. However, if helium should get into the line, the engine may fire roughly sometime during the first several seconds of a firing.

This anomaly is closed.

GOVERNMENT-FURNISHED EQUIPMENT

AIR BUBBLES IN LIQUID COOLED GARMENT

After the Lunar Module Pilot removed his liquid cooled garment on extravehicular activity day, he noted many air bubbles entrained in the liquid tubes.

The preflight charging procedure for the portable life support system has been reexamined for the possibility of air inclusion into the system during charging, and the possibility was eliminated. The air most probably entered the system during connection of the portable life support system to the liquid cooled garment in the pressurized lunar module cabin. Because of the location of the coolant make-up line for the portable life support system, when the total pressure in the liquid cooled garment is less than that in the portable life support system, air is ingested through the sublimator into the coolant loop. A design change to the portable life support system to eliminate this problem is in process and will be available for the Apollo 11 hardware (see fig. 22). This change will relocate the make-up line to the upstream side of the water shutoff and relief valve. Any pressure make-up will be replenished with water instead of gas.

This anomaly is closed.

STOWAGE OF OXYGEN PURGE SYSTEM PALLET

The crew could not insert the locking pin through the lunar module bulkhead structure into the oxygen purge system pallet when restowing the purge system and pallet. The location of the hole in the bulkhead bracket, adjacent structure, lighting, and angle of insertion caused difficulty in aligning and inserting the pin. This mission was the only one on which this kind of pallet will be used and the only mission on which the oxygen purge system will be stowed in this location. The same type pin will be used on LM-4 and LM-5 to hold the portable life support system by the recharge station, where the lighting and alignment access are good.

This anomaly is closed.

LIGHTING FOR CREWMAN OPTICAL ALIGNMENT SIGHT

Crew comments indicated that during docking at 99 hours, the brightness of the background and the sunlit command module "washed out" the reticle image in the lunar module crewman optical alignment sight. This problem was caused by the neutral density filter, which was housed in the barrel assembly to limit brightness of the reticle pattern. This filter will be replaced with a diffuser glass, and an external snap-on filter will be provided for attachment over the forward end of the barrel. With the filter removed, the brightness of the reticle pattern is increased to allow the reticle image to be visible against a 10 000 to 16 000 foot-lambert glare background. This change will be implemented on Apollo 10.

This anomaly is closed.

OXYGEN PURGE SYSTEM LIGHT

The checkout light on the Commander's oxygen purge system became erratic during the flight and failed to come on during preparations for rendezvous. An examination of all possible conditions which could have caused the checkout light to fail indicates that the main power switch actuator mechanism did not close the switch. Changes incorporated into the actuator mechanism for Apollo 10 and subsequent are:

1. Change type of Teflon insert material in the flexible cable

2. Change to a swivel joint in the flexible cable at the oxygen purge system interface

3. Increase cam rise on switch actuator cam

4. Bond switch actuator cam to slide

5. Bond switch in place after adjustment.

This anomaly is closed.

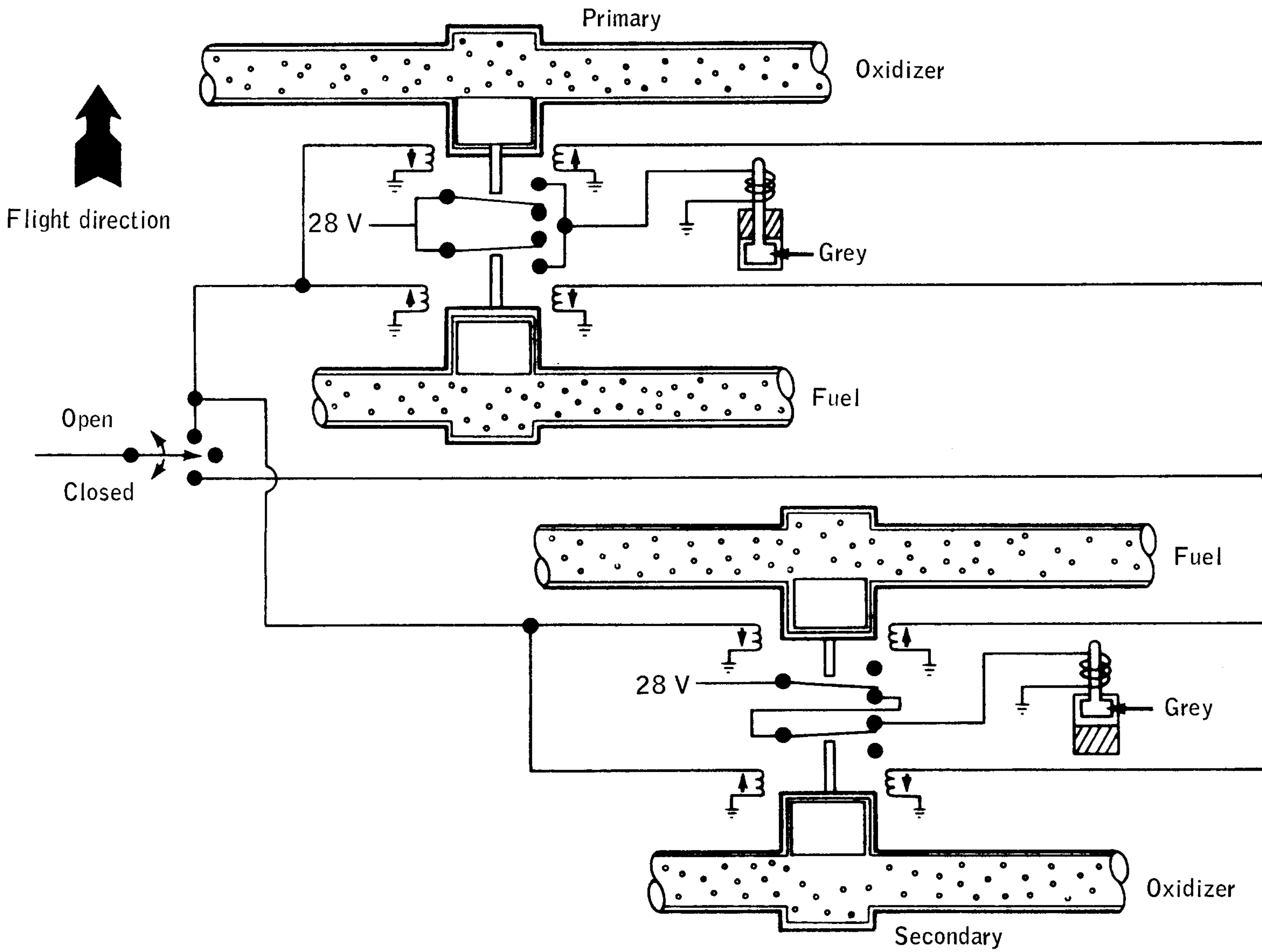

Figure 1.- Reaction control isolation valve.

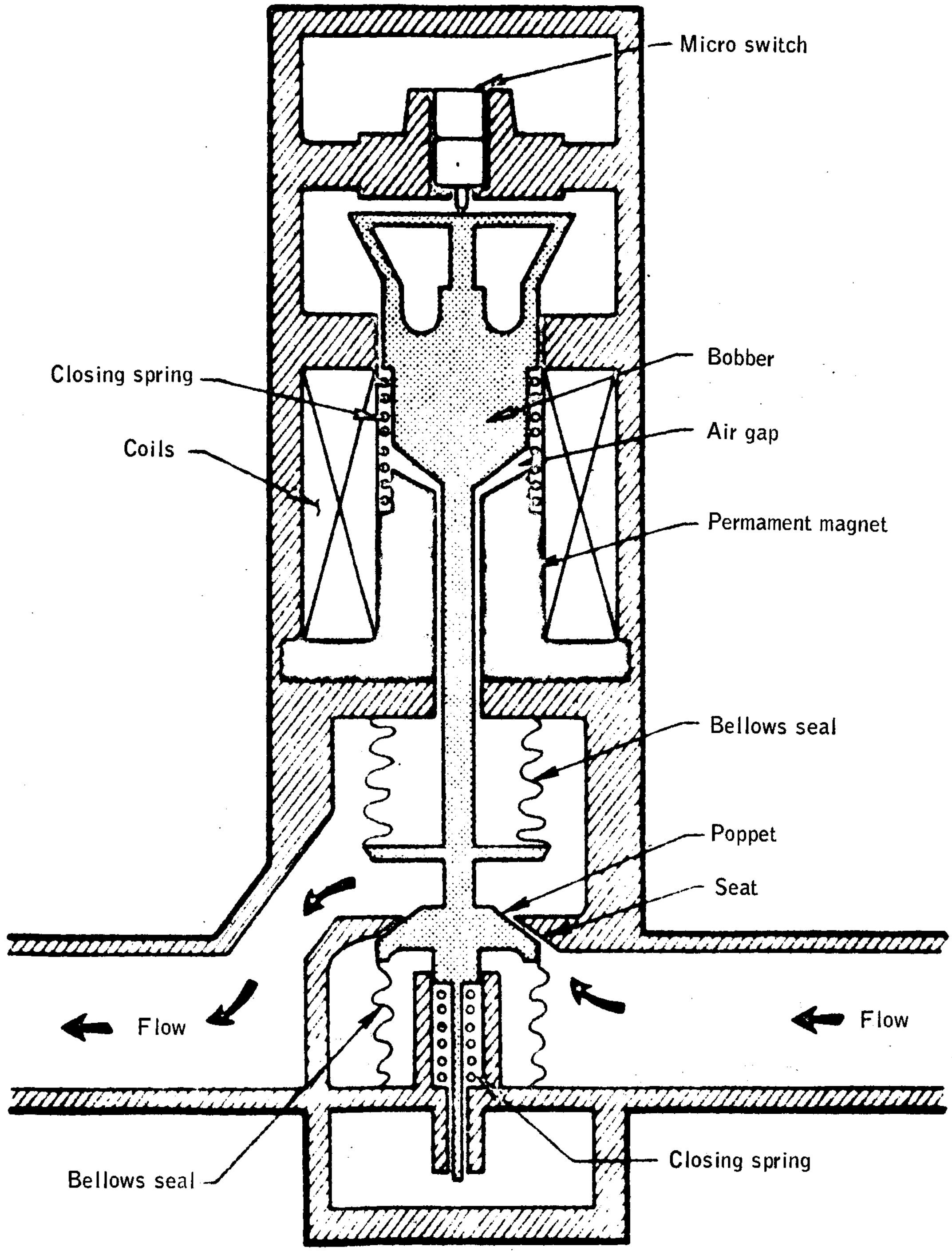

Figure 2.- Cross section of reaction control system isolation valve.

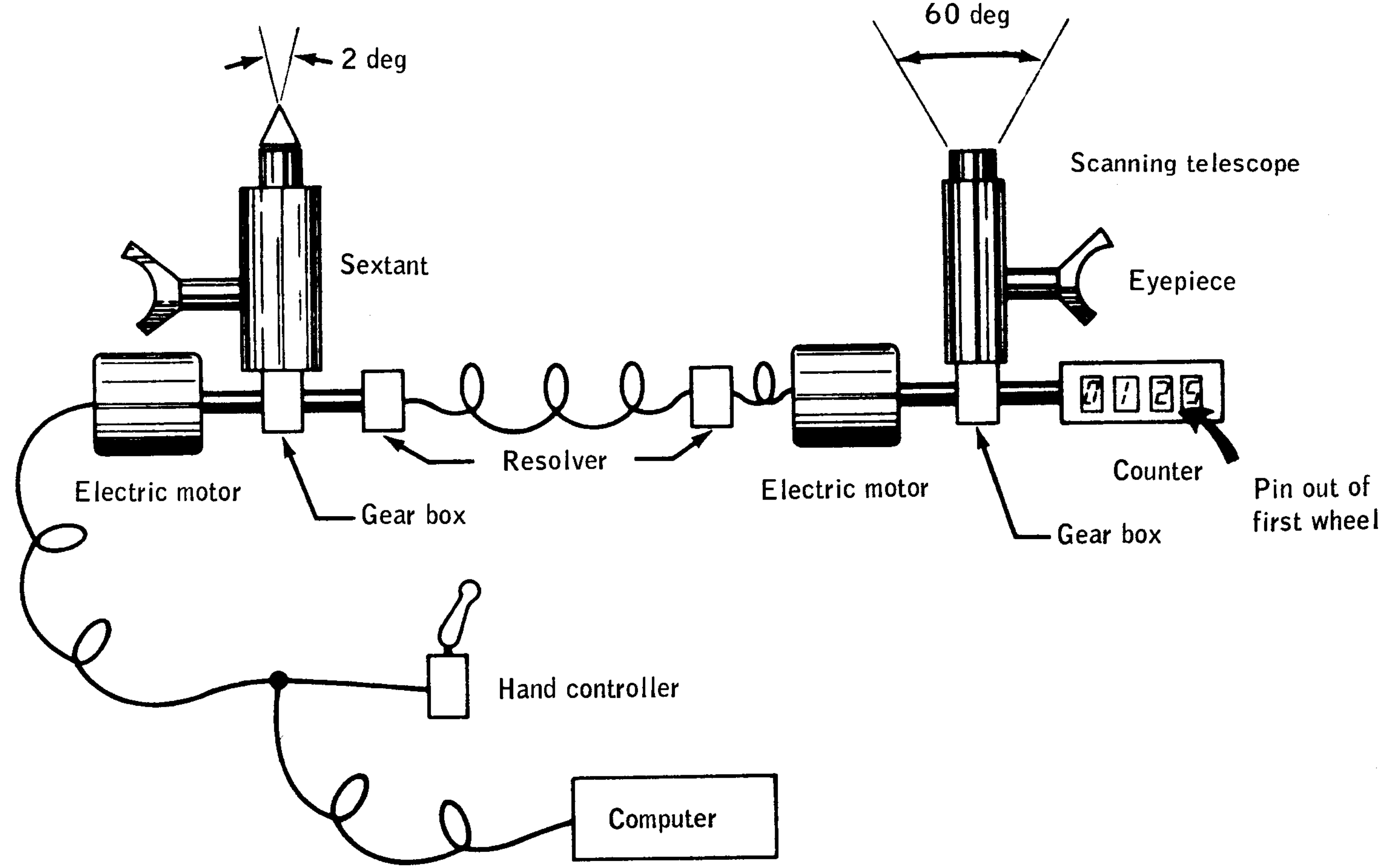

Figure 3.- Scanning telescope counter.

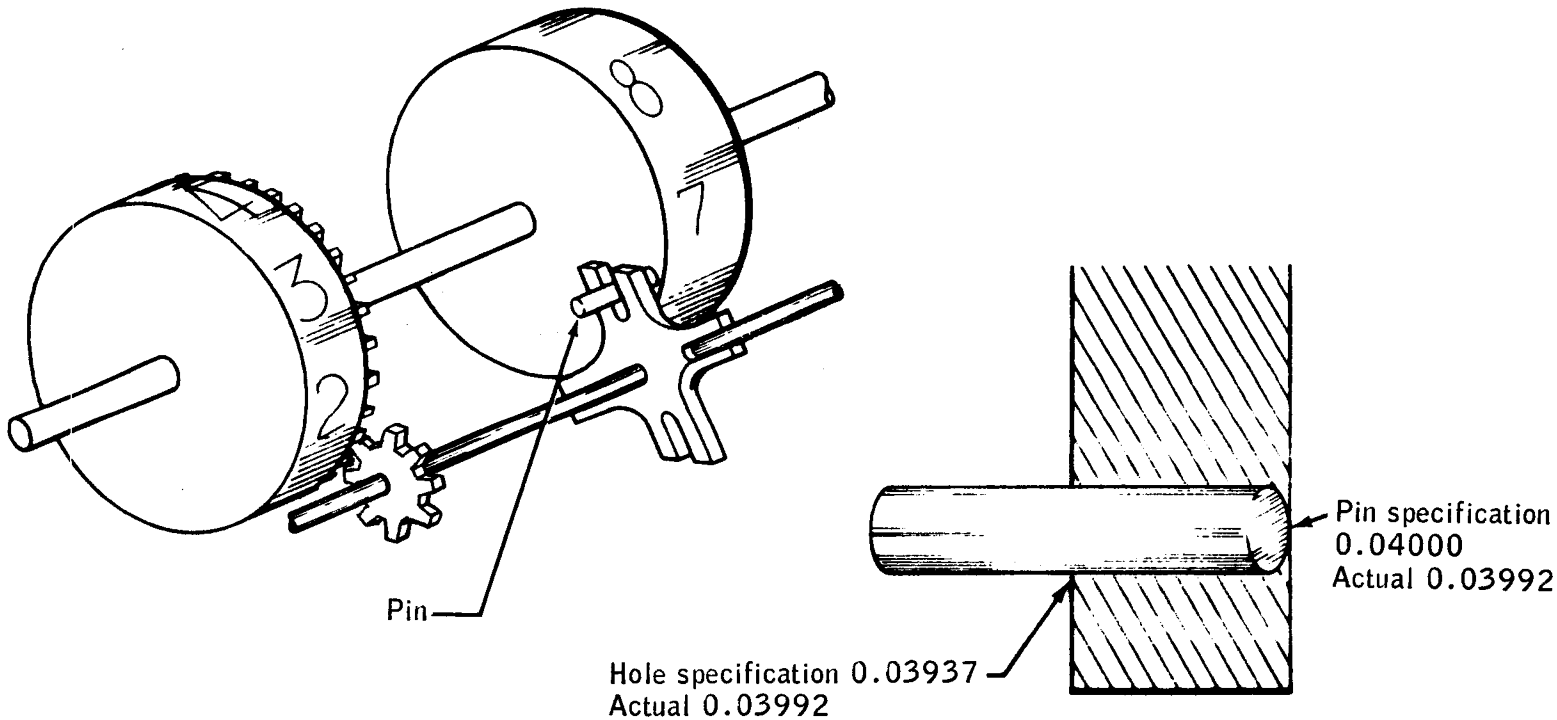

Figure 4.- Scanning telescope counter.

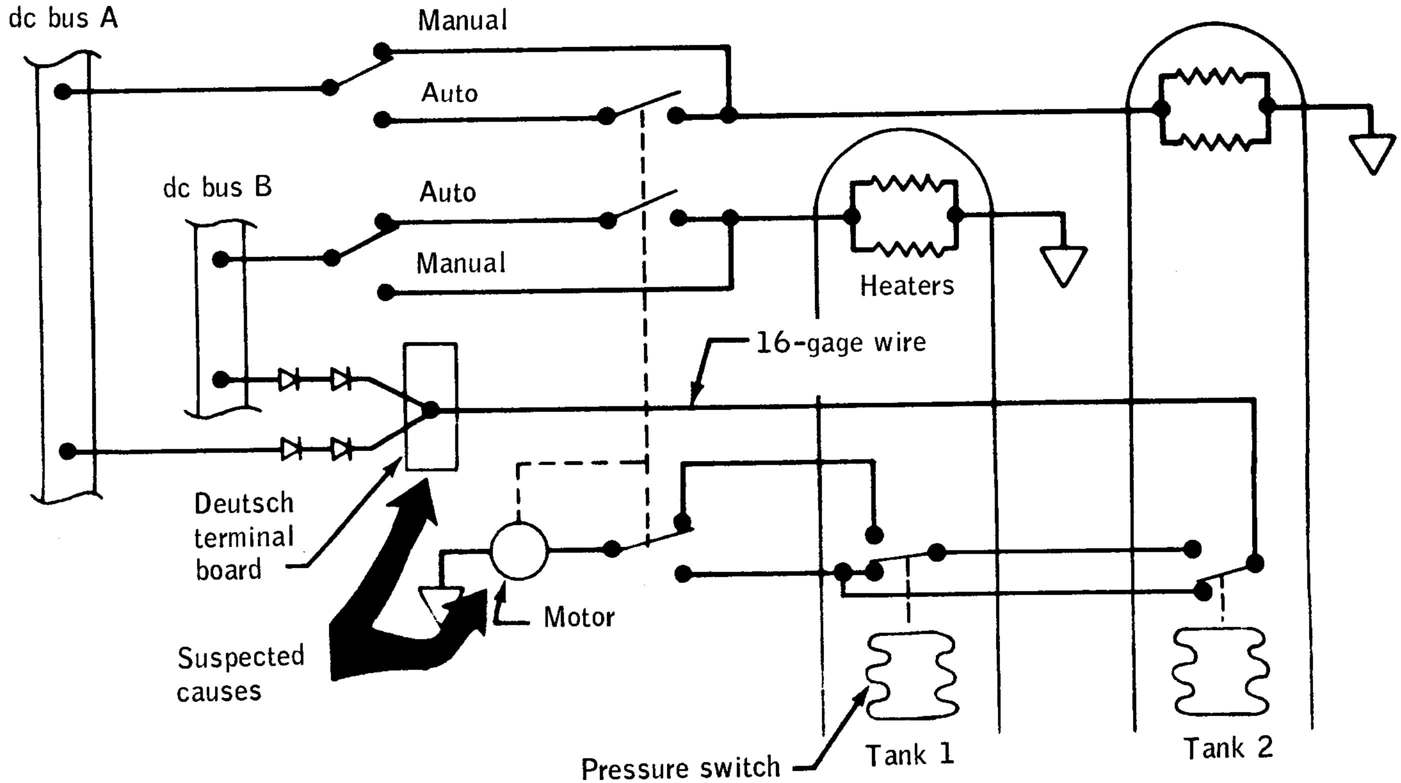

Figure 5.- Hydrogen tank pressure control.

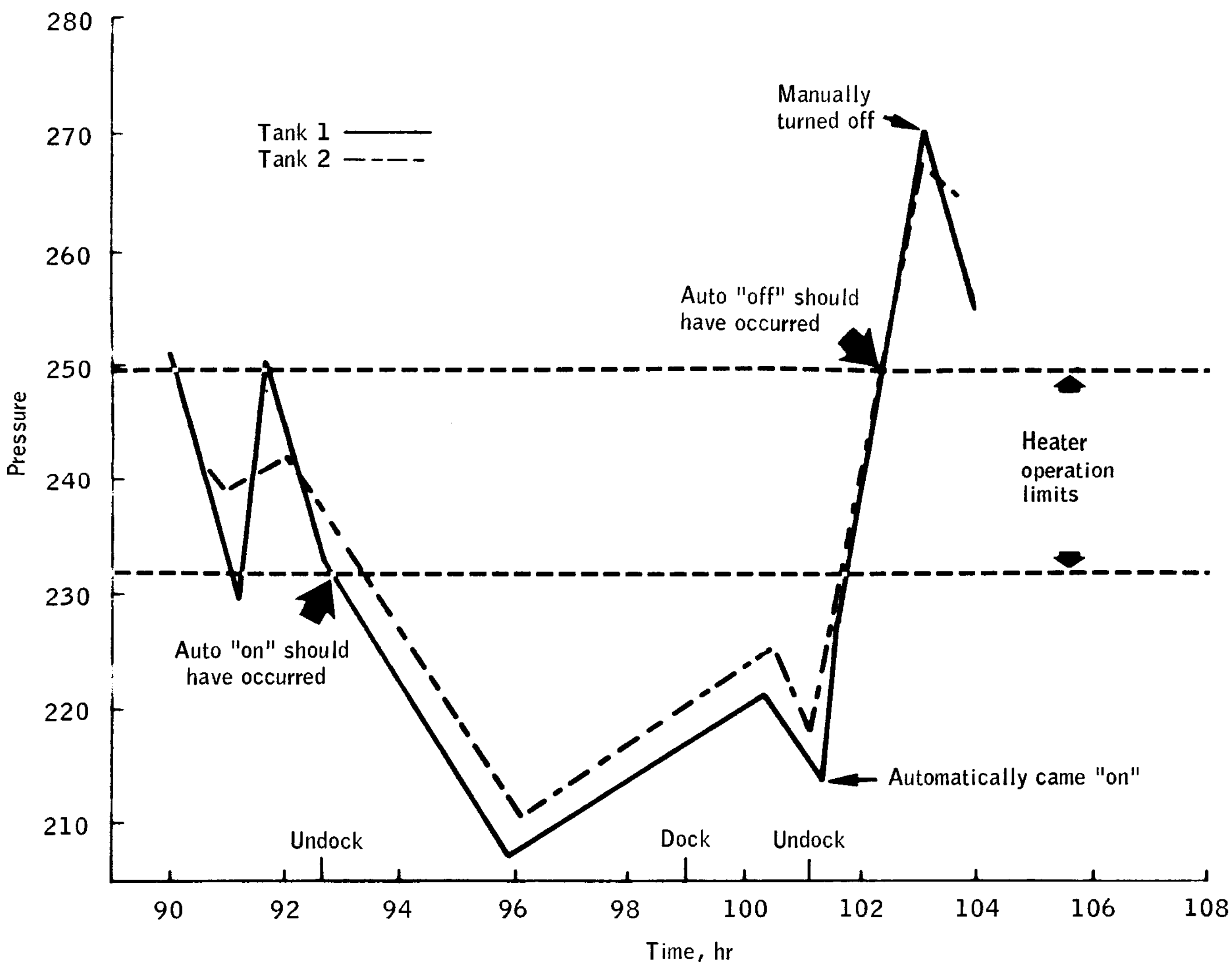

Figure 6.- Hydrogen tank pressure - heater operation.

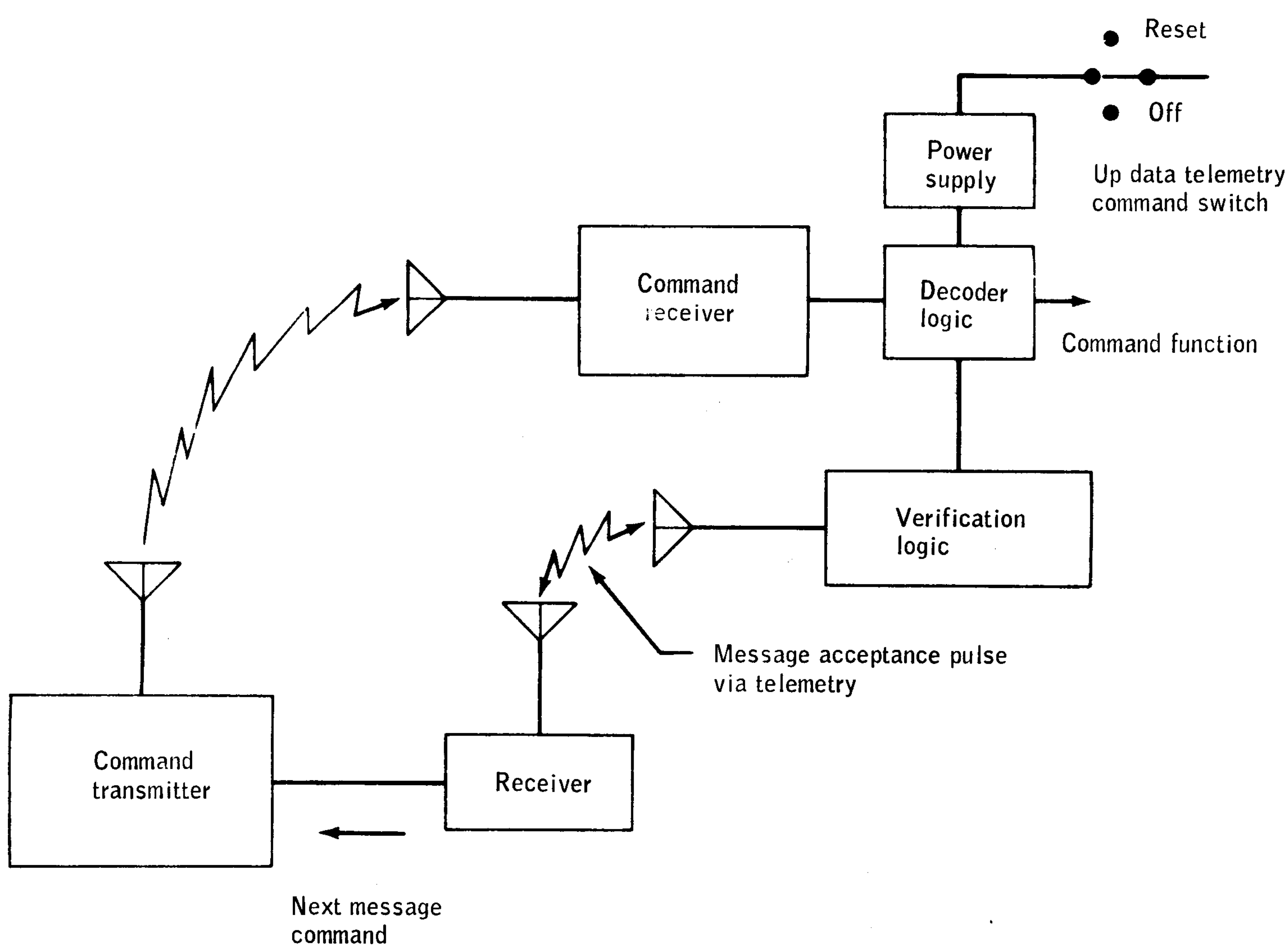

Figure 7.- Command link.

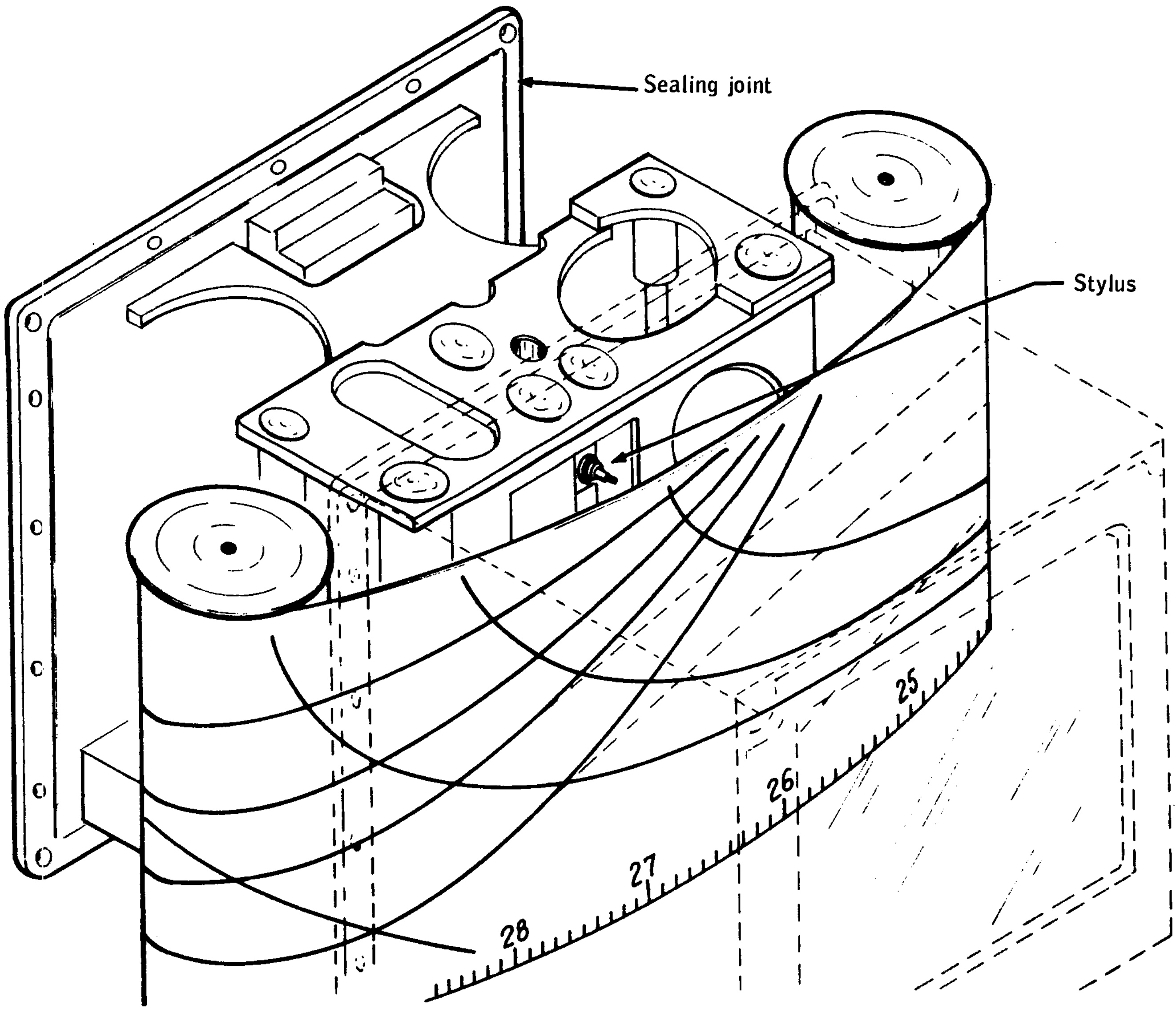

Figure 8.- Entry monitor system.

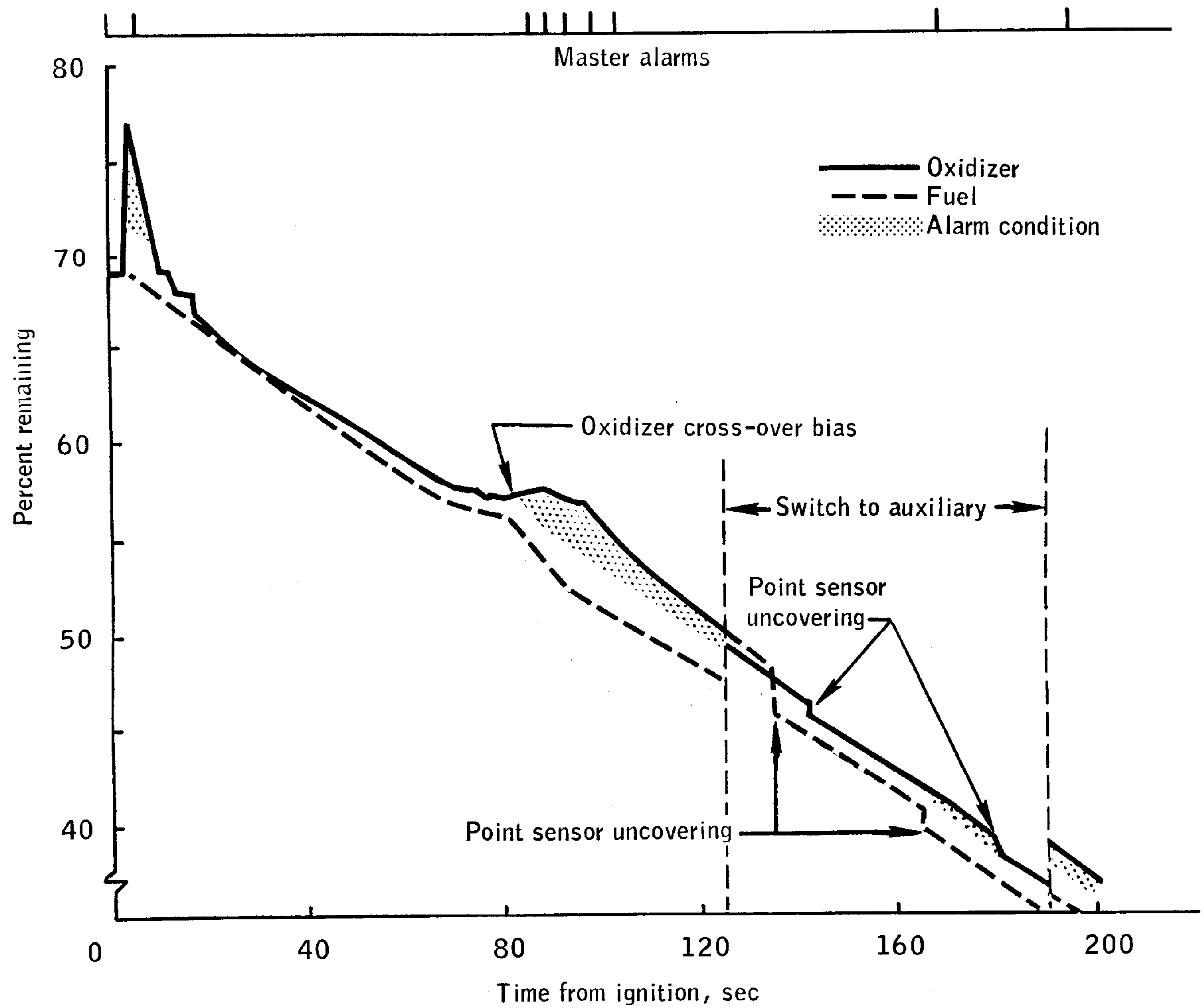

Figure 9.- Service propulsion system propellant quantities.

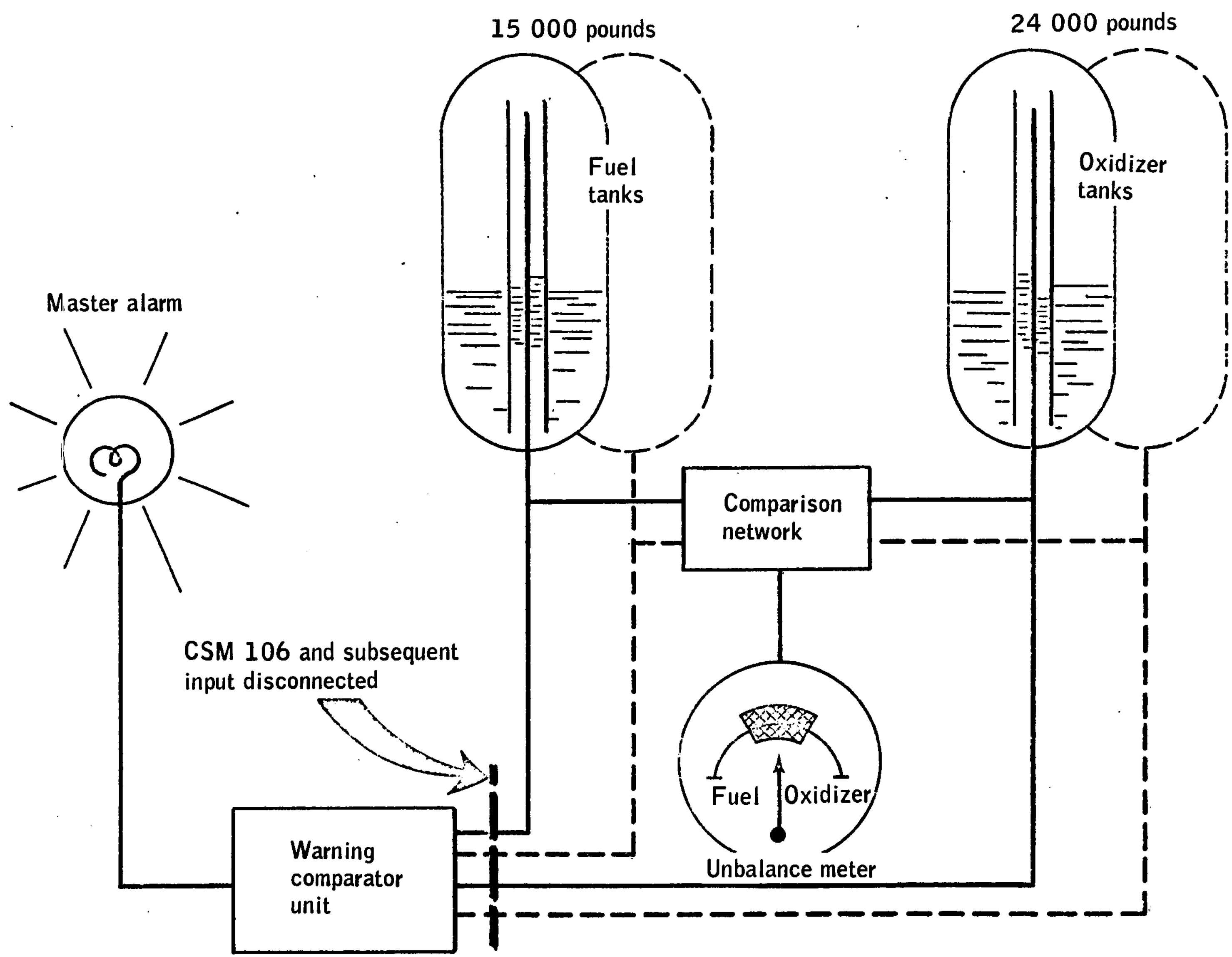

Figure 10.- Primary propellant utilization system circuit.

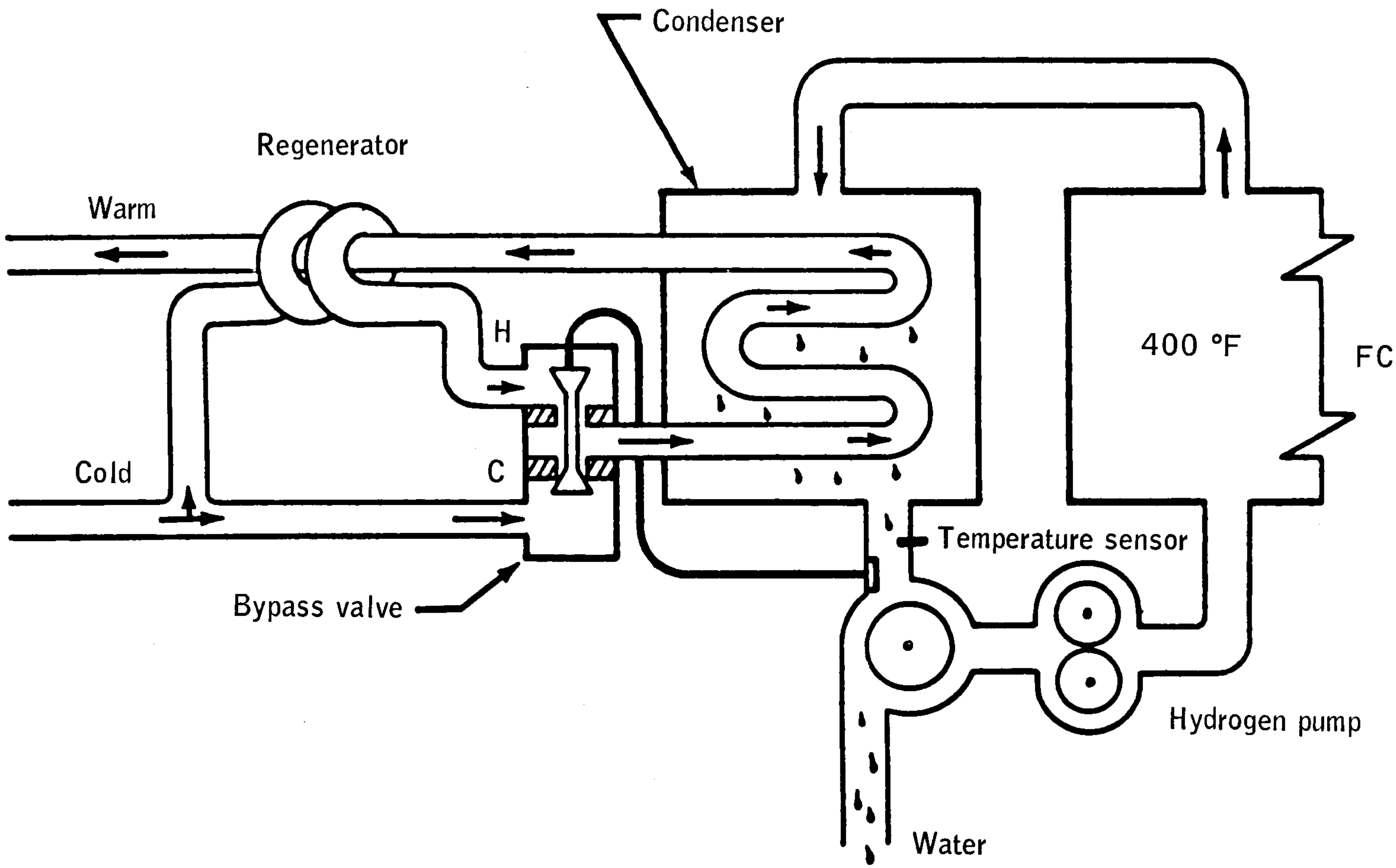

Figure 11.- Condenser system.

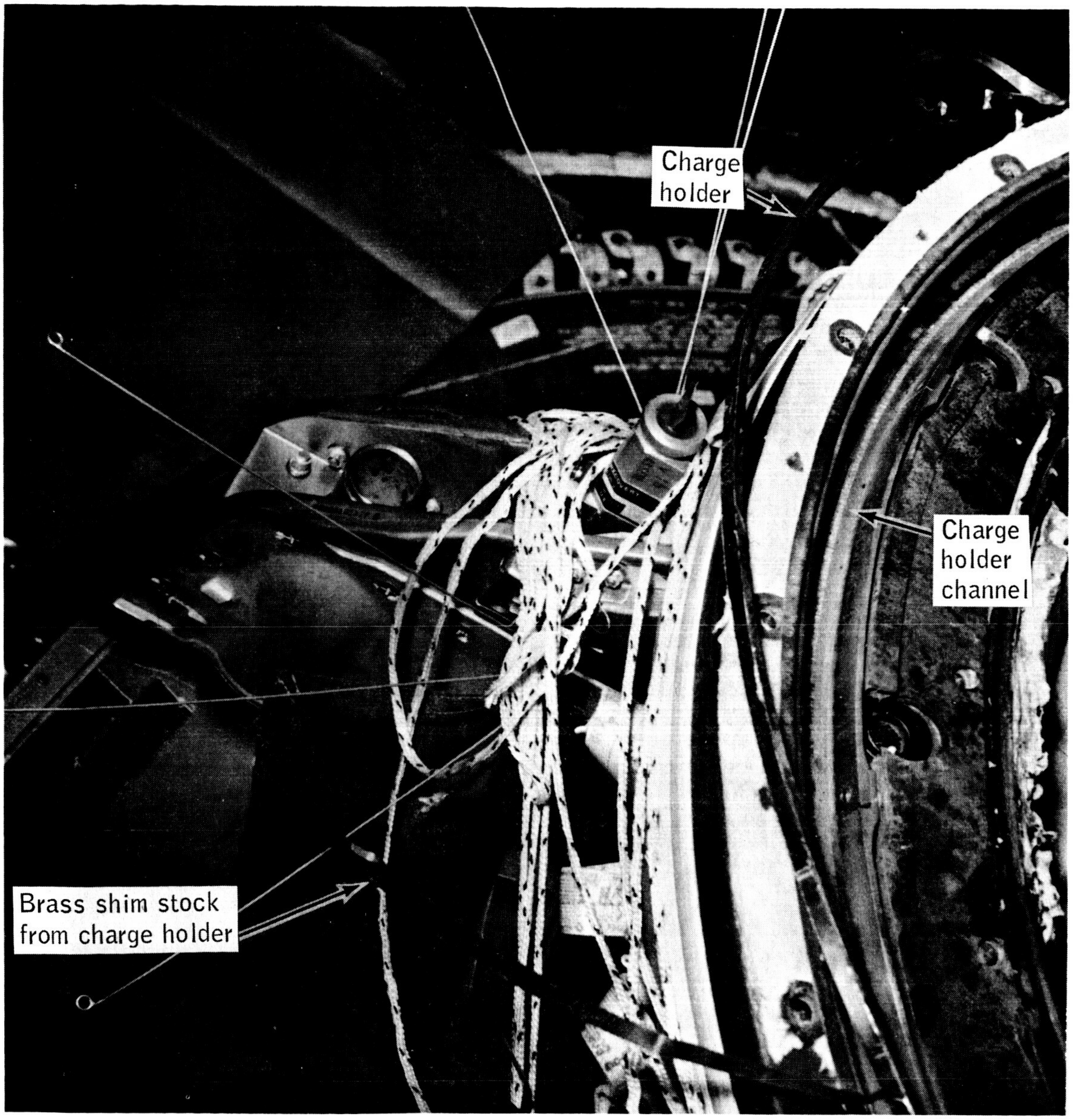

Figure 12.- Top of tunnel structure after recovery.

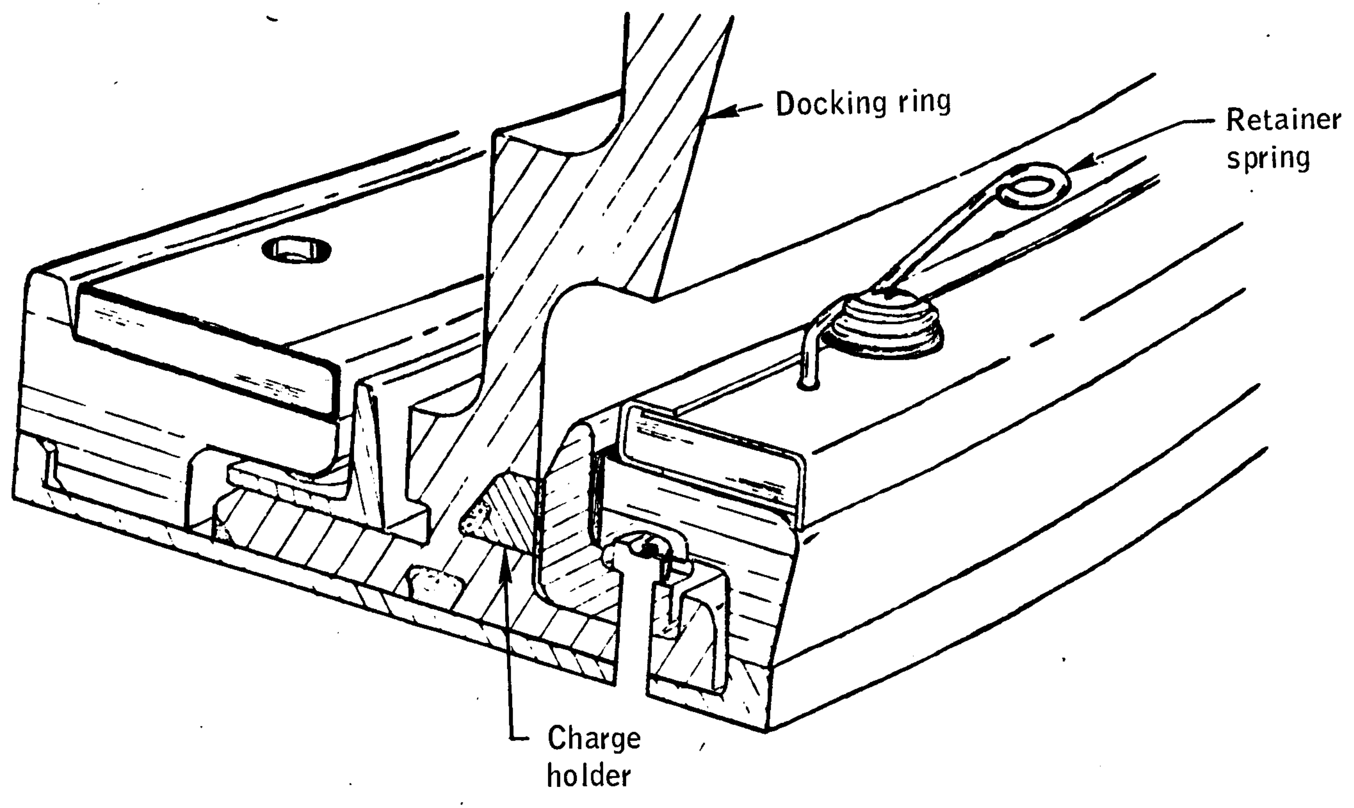

Figure 13.- Charge holder retainer spring.

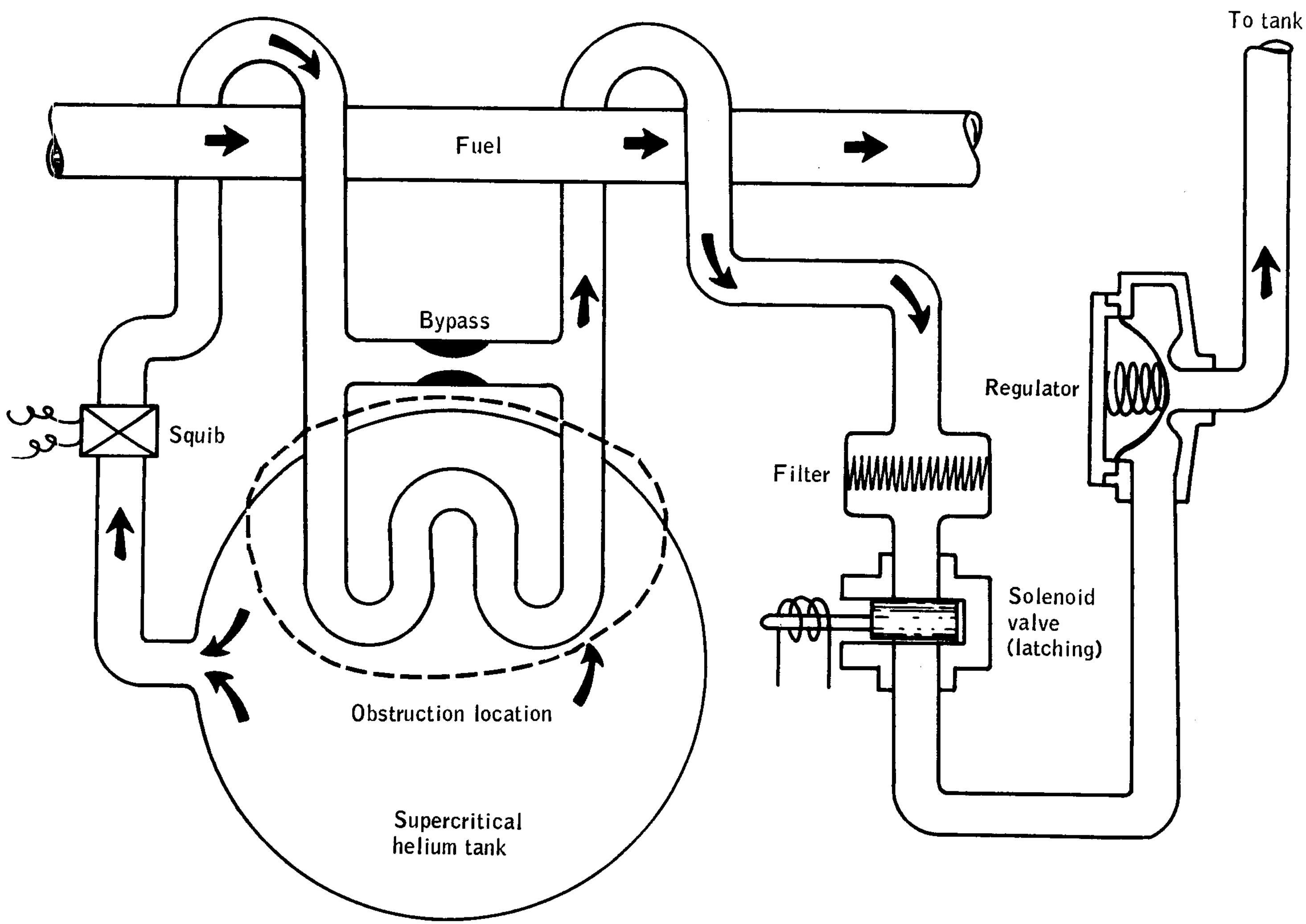

Figure 14.- Supercritical helium system.

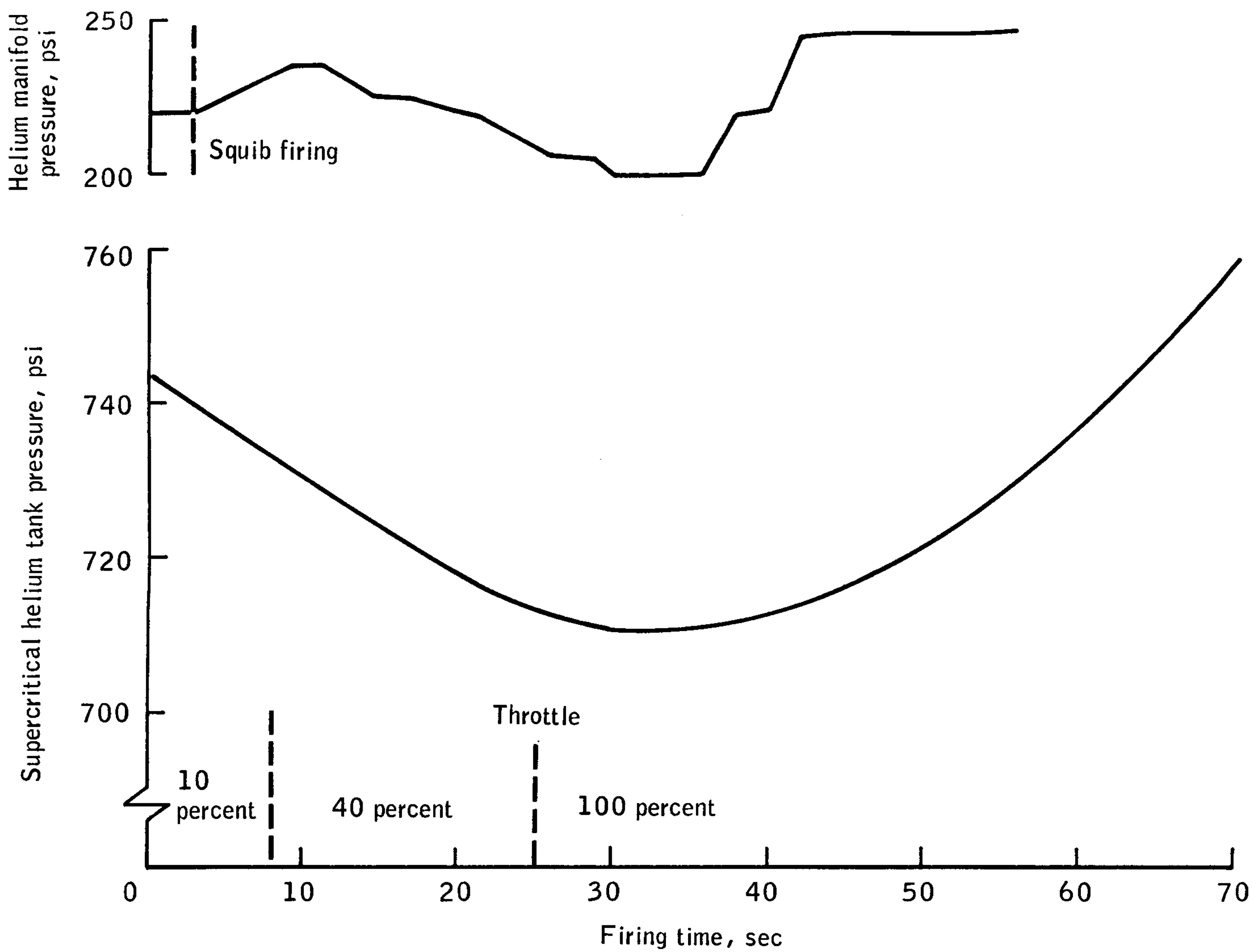

Figure 15.- Supercritical helium tank blockage data.

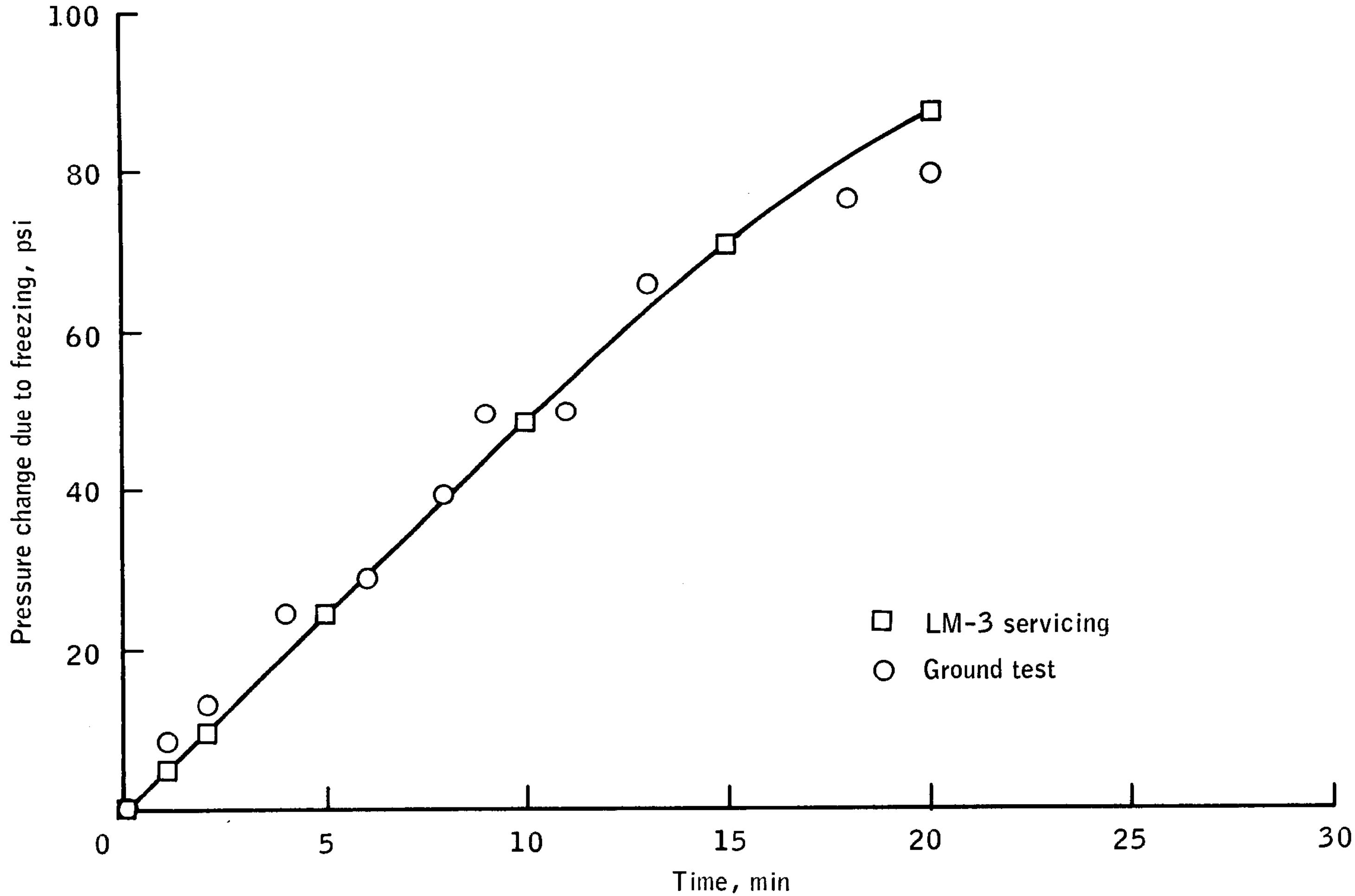

Figure 16.- Supercritical helium tank pressure rise.

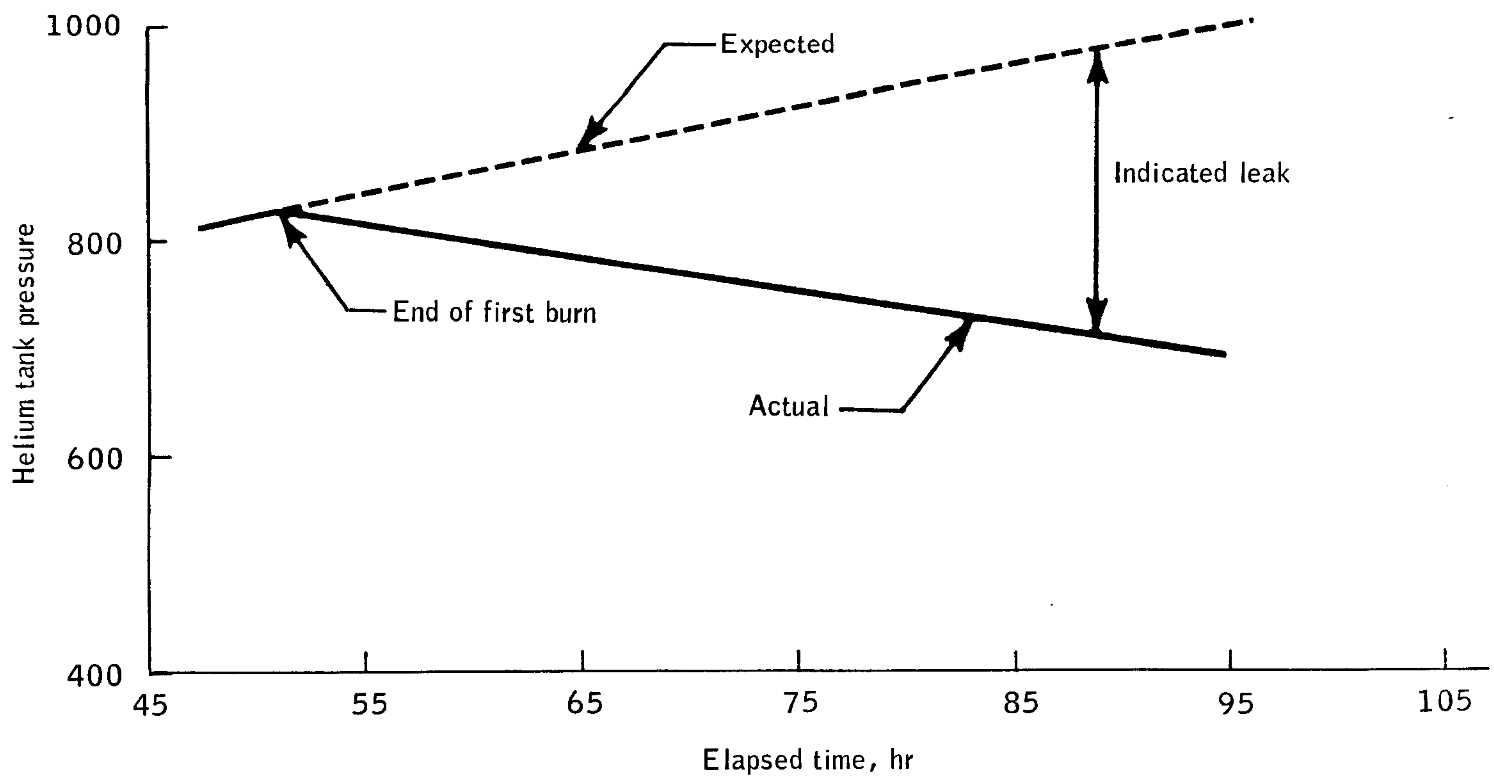

Figure 17.- Supercritical helium pressure decay.

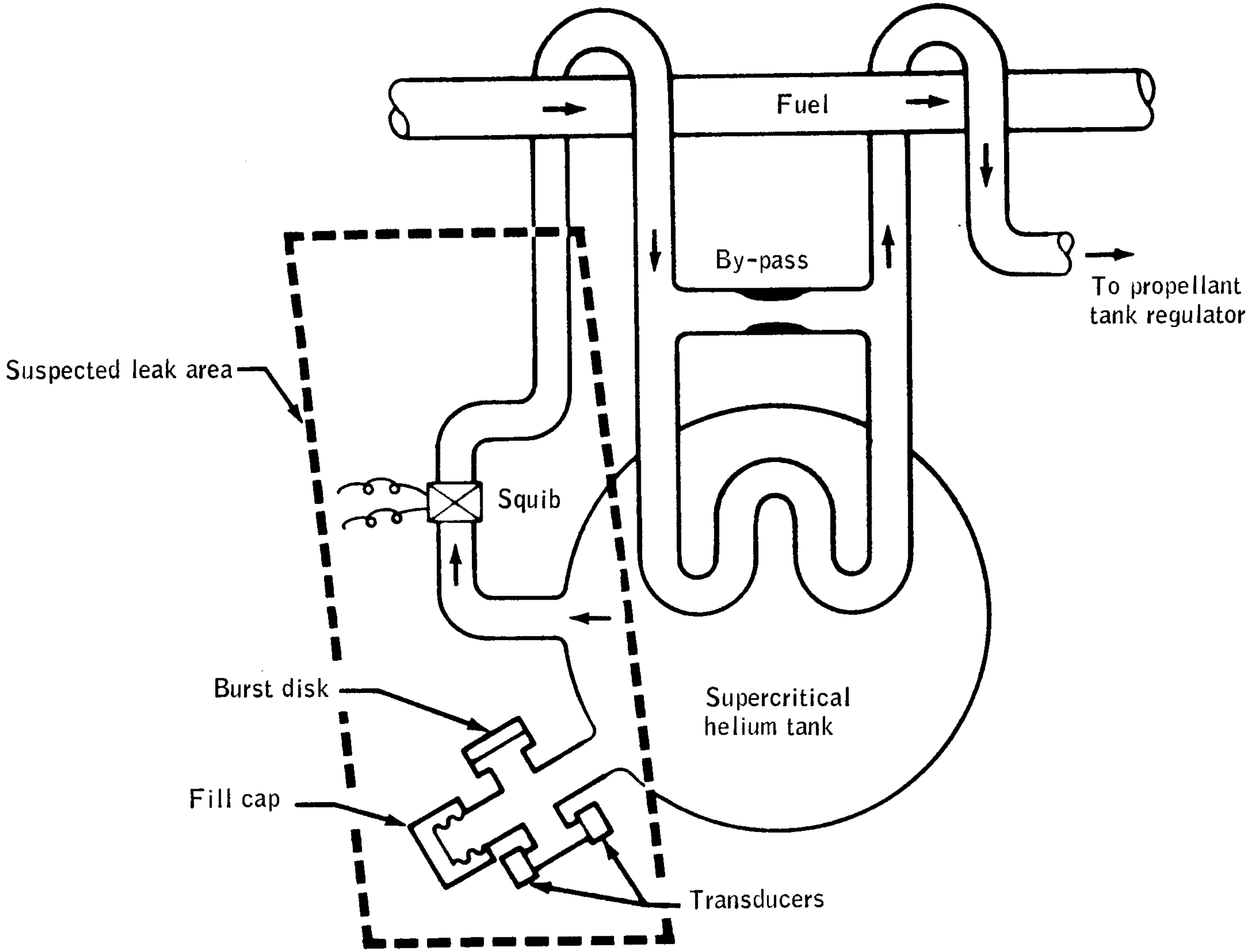

Figure 18.- Supercritical helium pressure decay.

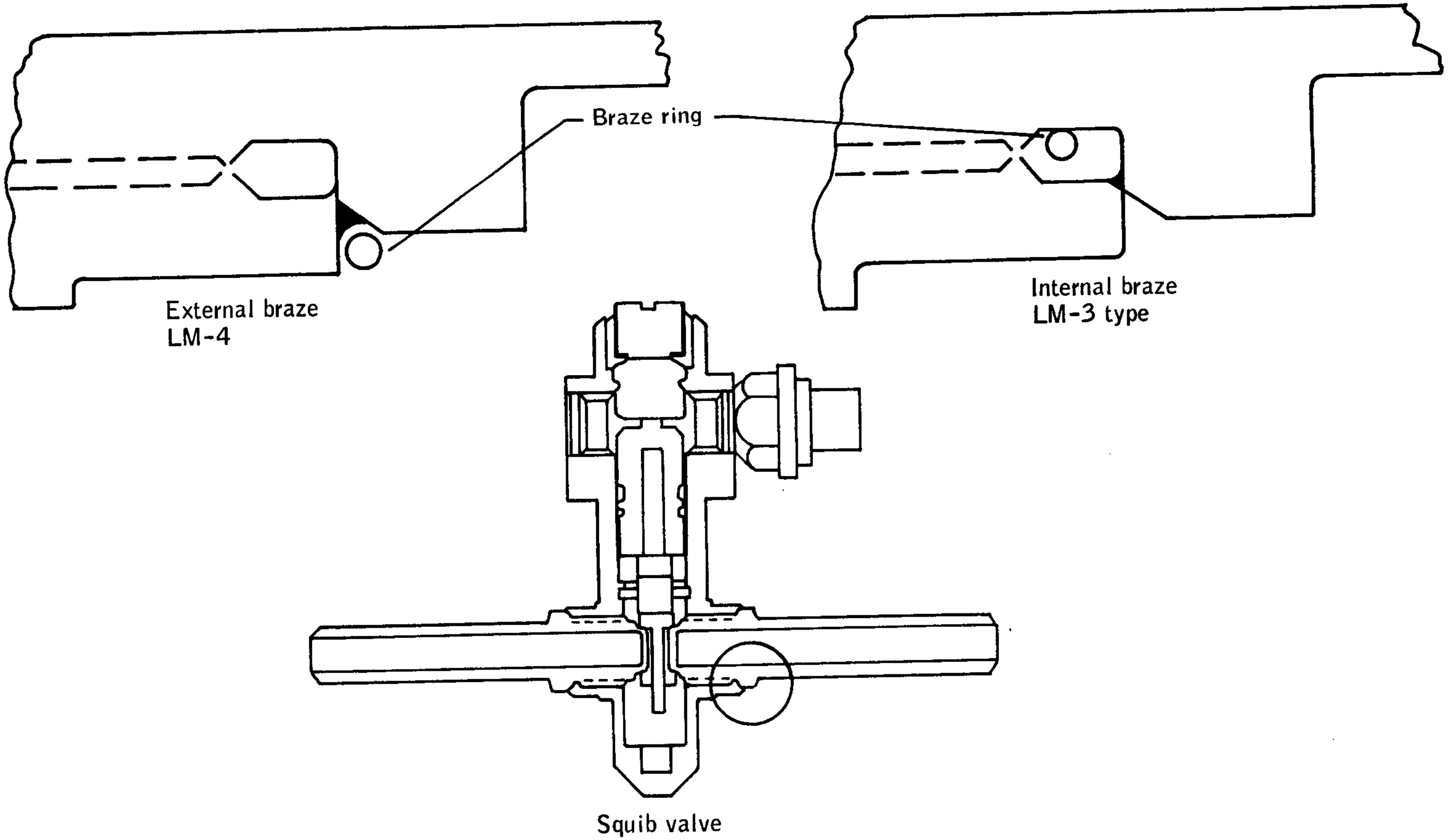

Figure 19.- Supercritical helium squib valve configurations.

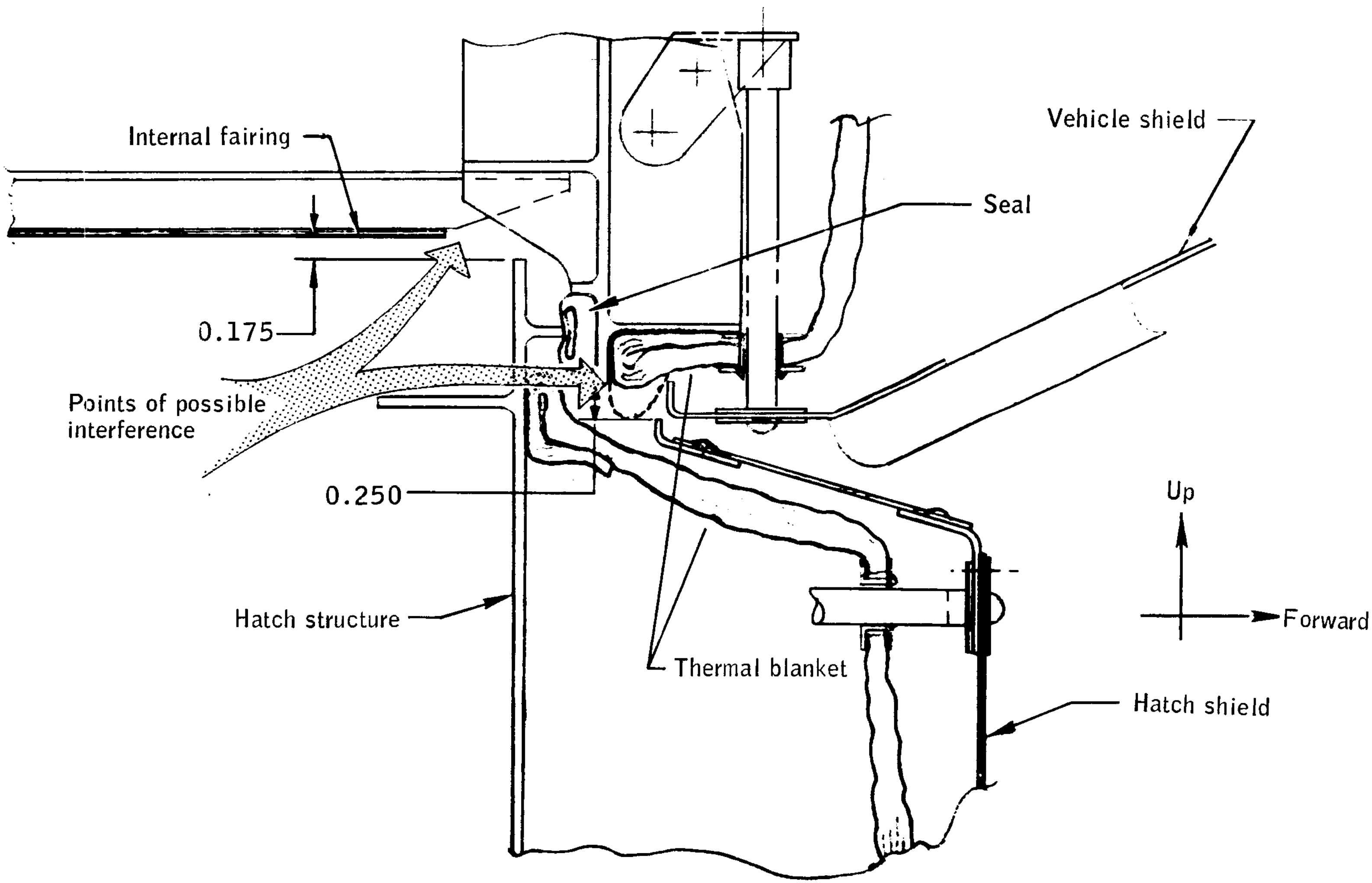

Figure 20.- Potential hatch interferences.

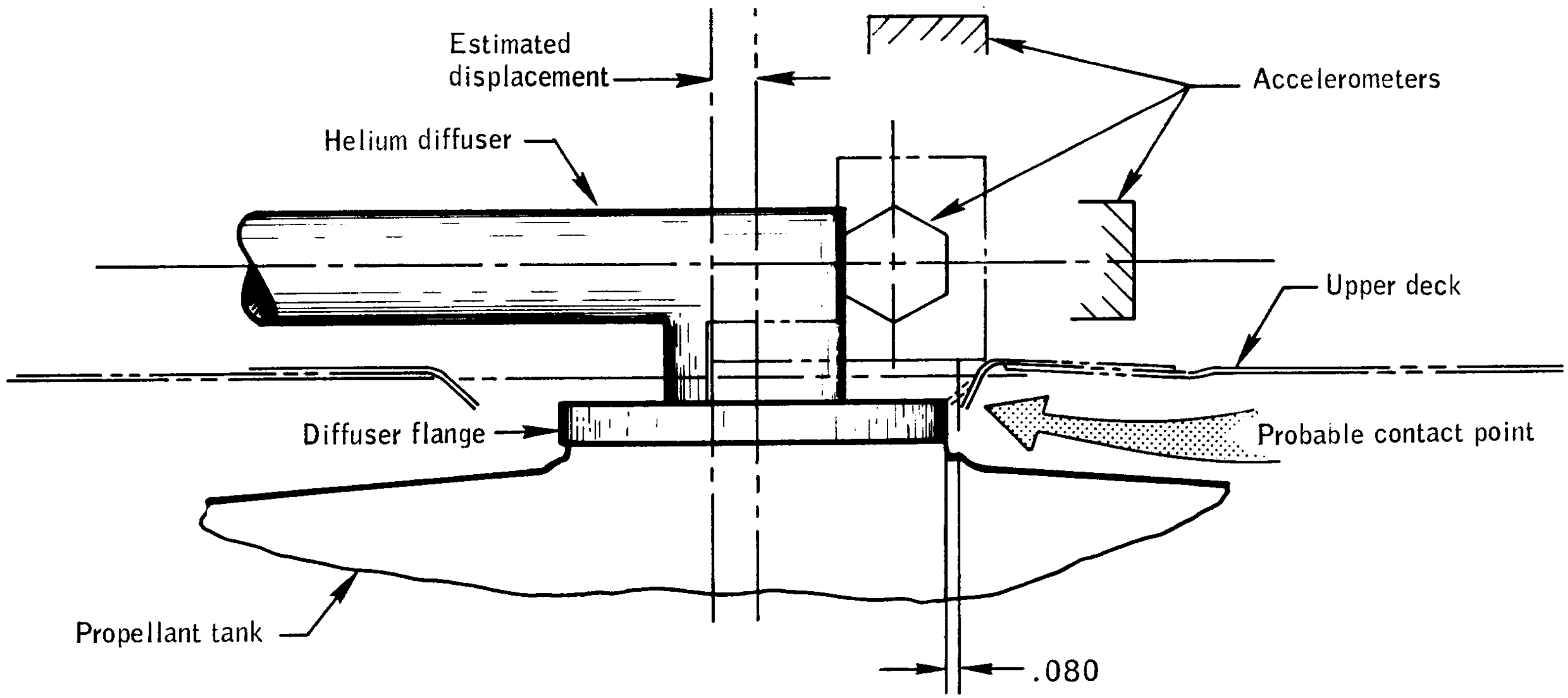

Figure 21.- Probable tank-to-upper-deck contact point.

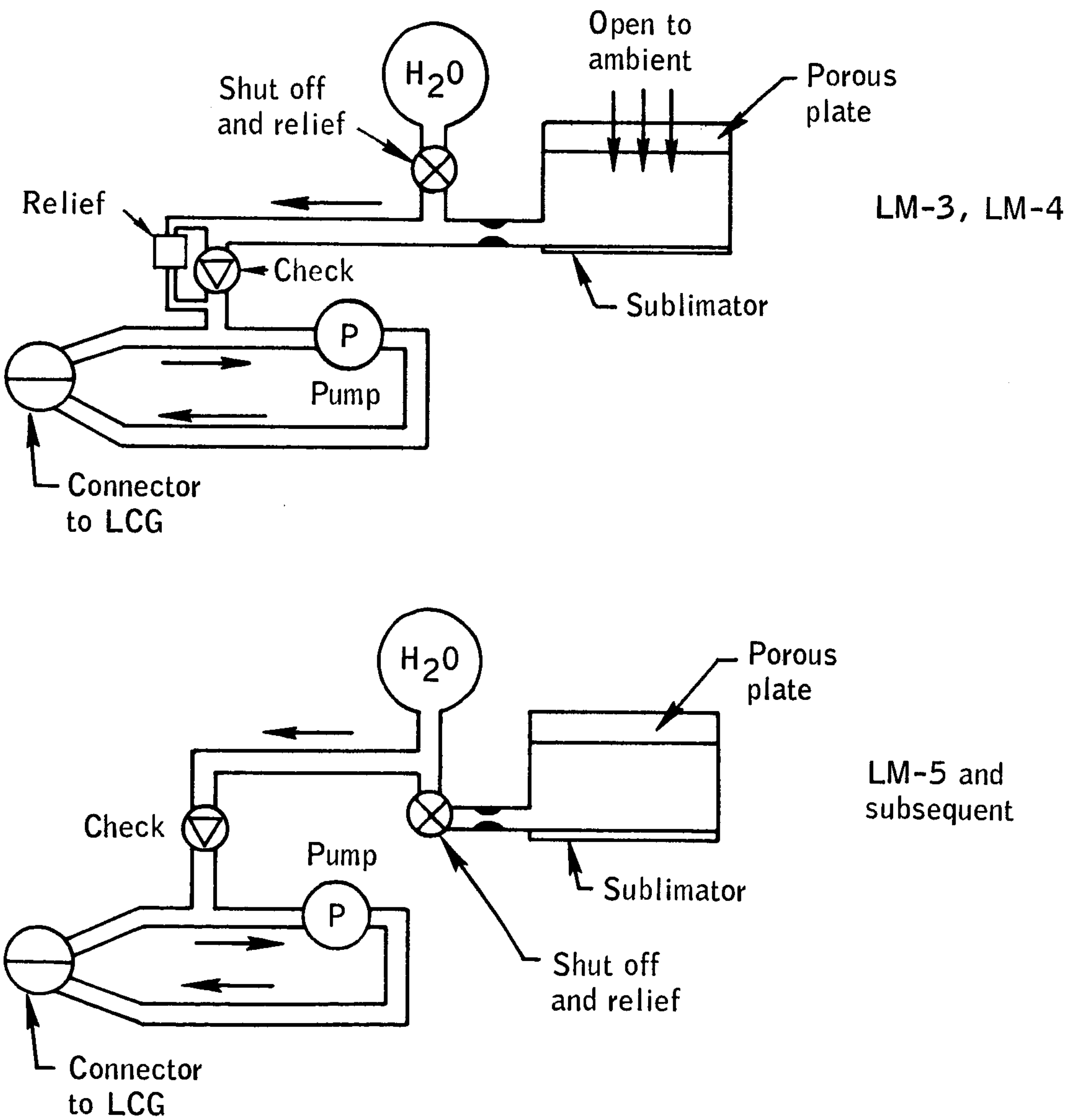

Figure 22.- Air in liquid cooled garment at time of connection to PLSS.